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Correspondence with the United States Board of Navy Commissioners, being replies to their circular asking information relative to Steam Navigation, applicable to Government purposes.

(Continued from Vol. xi, page 380.)

To Com. Lewis Warrington, *President of the Board of Navy Commissioners, Washington:*

Sir,—In examining, in my last letter, the allegations which we have seen advanced by two patriotic and able writers, against our mercantile steam vessels, I was led to notice, incidentally, some of the most important and valuable qualities pertaining to these vessels; and which now appear to demand the attention of the government. The question of the *relative strength* and security of the light built and finely modeled classes of American steamers, however, was not specially examined, and now claims our consideration.

In my second letter to Commodore Perry, I have alluded, in general terms, to the great injury arising from unnecessary or redundant *weight*, in the construction of a steam vessel, and to the comparative *weakness*, instead of strength, which necessarily results therefrom. I now maintain that the average quantity and weight of materials employed in the construction of steamers of classes C and D of our table, is fully sufficient for their best security, for any judicious purposes of war or commerce; and that the hulls of these vessels, even as now

constructed, are quite superior in *comparative* strength and sea-worthiness to the average classes of merchant vessels, heavy steamers and ships of war.

The facts and considerations, which have been adduced in the foregoing examinations, are probably sufficient to sustain this position; but I prefer, for further illustration, to compare the construction of these light steamers with that of the magnificent steam ships of class A. Now the floor frames or timbers of classes C and D, forming the base of construction, are moulded nearly, if not quite, as deep as those of the steam ships; but are sided, however, to a much reduced width or thickness, thus affording a more advantageous selection and application of the material, and dispensing with an unnecessary and injurious weight. Instead of half floors and double-futtocks, by which the frames of the ships are often greatly weakened, nearly all the timbers of class C are whole at the keel, and extend to the sides of the vessel, where, by means of a well selected and proportioned futtock, and top timber, the frame is extended to the deck with but one joint or breakage, which is most strongly supported. It is probable, however, that the *frames* of either of the four classes in the table have strength much more than sufficient to resist any external pressure or other strain which can possibly accrue to a water borne vessel, properly loaded. But the actual strain upon the frames of each class in a sea-way, the *length* being equal, will be nearly in proportion to the square of the diameter of the vessel, and its entire weight; except as this strain may be increased by the want of heavy plunges and active buoyancy. Hence, although there is more space between the frames of the light classes than in the heavy steam ships, yet the available strength of the frames and other material, *as compared with the weight and amount of strain* respectively, will be found greater than in the class of heavy built steam ships.

In regard to the longitudinal frame work and the keelsons, by which the lateral frames or ribs are connected together in one firm structure, I may state that the keelsons of the light classes are as numerous as in the large steam ships of three times their tonnage, and four times their weight; and that the sizes of these keelsons are, at least, in equal proportion to the weight of the vessels: while the longitudinal framing at the turn of the bottom or bilge, and also at the line of the deck, parts of vital importance to the strength and security of a steam vessel, exceed, in *comparative* strength, security of fitting and longitudinal tenacity, those of any other vessels known. These connexions are bound together, laterally, in the strongest manner, by large screw bolts passing through the frames from outside to inside; no less than *four thousand* of these bolts being sometimes used in the construction of a common steamer. The framing and securities of the decks of these steamers are also arranged in such a manner as to dispense with a great amount of unnecessary and injurious weight, while their durability and available strength are thus greatly increased.

Thus it will appear that these steam vessels are constructed and secured in a manner well calculated to relieve the frames and planking from injurious strain in a sea-way. Their sides, also, are often

supported by diagonal framing or ceilings, securely fastened upon the interior portions of the frame; so that the general frame work of these vessels is in all respects as safe and unexceptionable as that adopted for the heavy steam ships.

But after all, the chief danger from weakness or dislocation in a steam vessel at sea, pertains to the external planking, which must necessarily sustain the maximum tension of the vessel; and, without a loosening or disjoining of the seams by longitudinal or tortuous strains, there can be no hazard to a water borne steamer, except such as may arise from the want of sufficient buoyancy to keep out the sea, or from the disruption of the bottom, or of the water-pipes leading through the same, by some accident pertaining to the engine.

On comparing the strength of the outside planking in the several classes in the table, I find that the planks of some of the best steam ships of class A have a thickness of four inches for the bottom, and five inches for the sides of the vessel; while in class C the bottom planks are three inches, and those of the sides four inches in thickness. From this we may compute the areas of solid planking on the midship cross section of the sides and bottom of the steam ships as being equal *to twenty-seven square feet;* and, by the same approximate rule, that of the steamers of class C may be computed as averaging *twelve and a quarter feet.* Now the average of the entire weight of each of these two classes, as seen in line 6 of the table, is 2360 tons and 580 tons respectively: a proportion of *near four to one.* This shows the *comparative* strength of the planking in class C to be almost double to that of the best steam ships of class A. It is true, that the average length of the four coasting vessels of classes C and D exceeds that of the steam ships of class A, by an average difference of seven feet; but this is more than compensated by the greater ease and fineness of the head and stern in the two lighter classes.

We may safely claim, therefore, that American coast steamers, like those in the classes C and D, possess a degree of relative or comparative strength which exceeds that of the heavy steam ships employed in transatlantic navigation. I speak not, however, of the suitableness of their interior or exterior arrangements for the purposes of war, nor of the particular positions of their engines and boilers, but solely of their general proportions, the quantity and weight of their materials, and the tenacity of their construction. Any additional weight which may be *essential* for naval purposes may be more than compensated by that which can well be spared from these vessels.

But there are objectors who will doubtless refer with confident assurance to the loss of the American steamers Home, Pulaski and Savannah, as refuting my position. And the prevailing misapprehensions or delusions in regard to the first case here mentioned, and the unhappy influence of these errors upon our national interests, require that the case should be particularly noticed on this occasion.

I may first state, however, in regard to the Pulaski, the well known fact, that the loss of this vessel was directly occasioned by an explosion of the boiler; and the case, therefore, comes not within the scope of the present examination.

I may further premise, that the disasters and losses by coast steam navigation at the period of the loss of the Home, 1837, were by no means confined to that vessel: not less than eight British steamers having been wrecked or foundered in that year or the winter and season following, and great loss of life and property thus occasioned, not including here numerous other British losses of the same period, by collisions, fire, and the explosion of boilers. If, therefore, an American steamer was lost by stress of weather, it can afford no valid argument against American steam vessels.

But the American public has been led to believe, and I confess that I had myself yielded at first to the impression, that the loss of the Home was directly caused by a general straining of her hull, in a gale at sea, and from the want of adequate strength and tenacity in her general structure. This was so confidently argued and sworn to, that no one, unless particularly acquainted with all the facts of the case, could withhold his credence to the allegations.

After the lapse of more than three years, however, a legal investigation, full and elaborate, has been had of this case, and a most thorough inquiry has thus been made into all matters and circumstances relating to the qualifications and loss of the Home. Of the great mass of evidence thus brought to view, I have not room to speak in detail; but it may be sufficient to state, that the principal allegations so confidently urged against this vessel prove to have been founded only in the ignorance, the fears and the misapprehensions of a portion of the passengers: the most remarkable of these being persons who claimed to have knowledge and experience of nautical affairs.

The only immediate cause of the disaster was found in the vessel's having sprung a-leak, at some undiscoverable point, while weathering the shoals of Cape Hatteras in a gale from the North East, with an unusually bad sea. After weathering the shoals and bearing away to the southward of the Cape, this leak increased, until the fires were extinguished in the boilers: when, at the solicitation of passengers, the vessel was run upon the breakers of that dangerous coast, and the larger portion of the passengers and crew were drowned.

But this case is too important, in a professional view, to be summarily passed over; and it is hoped that the whole evidence will yet be given to the public. For, stimulated by the clamors arising from this distressing case, and that of the Pulaski, which soon followed, Congress has been induced to adopt a scheme of legislation tending greatly to discourage or destroy our steam navigation, particularly on the ocean, where our own laws will no longer permit an equal competition with foreigners. Similar clamors, founded on the more numerous disasters of the British coast navigation, and aided by the American example of legislation, were brought to bear on the British Parliament. But that government, notwithstanding its great predilection for penal laws and complex schemes of legislation, could not be induced to lay onerous restrictions upon steam navigation, which is so essential to national strength and prosperity. On the contrary, England has, by the direct appliance of her bounty and patronage,

at this very crisis found means to cover the Atlantic, Mediterranean and Indian Seas, with steamers of gigantic size; and now proudly contemplates the resistless power by which nations may be held to her will.

But to return to the Home. This unfortunate vessel was constructed and equipped by Mr. Allaire, an enterprising engineer, who had been engaged in the construction of engines and steam vessels almost from their first introduction. With a mind apt to appreciate the means necessary for safe navigation, he had ventured, some years previous to this period, to equip and send forth the David Brown, a truly American steamer, upon the waters of the Atlantic; which, notwithstanding the fears and predictions of nautical men, proved an excellent and sea-worthy steamer; which, in later years, has been employed in the West Indian seas, till now rendered by the climate unfit for service.

Two other steam vessels were successively placed on the route from New York to Charleston, by Mr. Allaire and his associates: each winning additional confidence and applause from the observant navigator. One of these vessels having been lost by error of the pilot, a third and still superior steamer was placed upon the route, replete with every improvement of proportions, strength and equipments, which years of experience in this navigation had suggested; and so entirely assured was the owner of her sea-worthiness, that no insurance was applied for, except on a fraction of her value, for the particular benefit of a private creditor. This vessel was the ill-fated Home.

The Home had, of course, been condemned in advance, by certain nautical prophets, as has been common in all early attempts at ocean steam navigation; and, on the completion of her first voyage, was greatly traduced, through the ignorant misapprehensions of passengers and others, many of whom had mistaken the arched form which had been given to her deck for its greater strength, and which was most strikingly visible at two points, forward and aft of the centre, which, viewed in connexion with the usual depression of the wheel guards at midships, was taken as conclusive evidence of that injurious strain which is designated by the term *hogged*. Another effective scarecrow had also been found in a single set of bearing-braces, above the gunwale, on each side, which were intended to distribute more extensively a part of the weight of the engine and boilers.* These braces, however, being placed at a very low angle, broke loose from their shoe or socket on the deck, at their forward ends, by the elastic movement of the vessel in a heavy sea, as might reasonably have been expected; causing a slight dislocation in some light work above the deck, which had been attached to these braces, and which formed the enclosure of an upper state-room on the guards, occupied by a passenger. This trivial accident on her first voyage, caused considerable fright among timid persons, who had been taught to believe that

* It should be noted here, that the boilers were placed in line, one before the other; a most favorable arrangement for extending their weight and equalizing the strain of the vessel.

almost every thing is wrong and extra-hazardous in American steam vessels; and the laying of a foot-mat over the end of the dislocated brace, while in Charleston, was construed into an act of desperate treachery to the lives of the traveling public.

On arriving at New York, on her return voyage, the vessel was strictly examined by her builder; and, except this harmless matter, and the loosening of a small piece of plank on one of the extraneous spondings, every thing was found in perfect condition.

The second voyage of the Home was made without any notable occurrence; but on leaving port on her third and fatal voyage, she was soon overtaken by a north-east gale, and, meeting with an injury in a feeding pipe of one of the boilers, she bore up for the Chesapeak. This injury having been temporarily repaired, she then stood on for Cape Hatteras; but, owing to the previous alteration of her course, made the land about sixty miles northward of the Cape—the sea at this time being heavy, and the gale increasing. Steering now nearly in the trough of the sea to weather the Cape, the Home passed over the Wimble Shoals on which the sea was then breaking with great fury, and three of the rollers broke on board, so far only as to dash inward one of the gangway boards on the outside of the guards, abaft the water-wheel, together with two or three of the sash windows of the light built saloon cabin, which occupied the greater part of the after deck; and this small affair was the only thing like the boarding by a sea which occurred to the Home during the whole of this trying occasion, till she was partially water-logged, and finally, though unwisely, run into the breakers of the outer sand-bar on the coast of North Carolina.

After passing the Wimble Shoals, the Home had been headed up still more to the eastward, in order to weather the Hatteras Shoals; and shortly before passing these shoals was discovered to have sprung a leak. Much search was made for the mysterious leak, but without success; and the melancholy result is already stated.

It of course happened, that the overhead braces of the Home again broke loose in this gale, at the same point as before: and to this circumstance, and to the elasticity necessarily and properly manifested in a vessel of her length in a rough sea-way, much of the unseasonable panic is to be ascribed which had early manifested itself among the passengers. The size and relative dimensions of the Home were but little below those of the Neptune, which has since run so successfully on sea routes, and at times in the very heaviest weather. But the elasticity of a vessel, (a quality inseparable from the materials used, and which is also *conservative of strength*, when not unequally and improperly opposed,) will, in its visible extent, be always as the *square* of the vessel's length, and inversely, perhaps, as the square of her depth. It appears that this elastic motion of the Home at each alternate vibration from the impact with the seas, was mostly seen in the forward body by observers standing aft; but in the after body by observers standing forward; and in both the forward and after body by observers at midships.

The extent of this motion was not strictly ascertained; but one of

the witnesses thought he saw the extremity of the dislocated brace move obliquely to and fro, past the joiner work remaining attached to the vessel, to the extreme extent of ten inches. This includes the aggregated range of the two opposite vibrations, the parts compared, moving in opposite directions at the same time, the braces remaining fast at their after ends were thrust forward by the lifting of the stern, thus meeting the lifting motion of the bow; and so *vice versa*. This may give a positive tangential motion at these points of two and a half inches in each direction, to produce the above result, and perhaps more. Now in a vessel of limited depth, and exceeding two hundred feet in length, the above is but a small vibration, and does not equal the degree of elasticity which is often shown in strong mahogany furniture, when standing unevenly on a floor. I have sprung vibrations, by means of my own weight, on the largest and finest trunk of squared white oak timber that I have yet seen, to the estimated extent of two feet; and I am informed by Capt. Ericsson, that the steam ship British Queen, a vessel of nearly *twice* the depth and width of the Home, has vibrated in a gale to the extent of *eighteen inches*.

As the elasticity shown by the Home was naturally associated in the minds of the passengers with the dislocation of the braces, and was more particularly noticed by them near this point, this motion was considered by many as having caused the subsequent leak and disaster, by straining the sides. But those who understand the construction of this vessel know that her deck presented the weakest surface of tension; in which no one pretends the butts had opened in the slightest degree. The sides come next in the order of strength and tenacity; and her bottom was greatly the strongest of all. Therefore, if there was any straining or opening of the seams to produce dangerous leakage, it must have been in her sides. I have since had the satisfaction of examining a portion of the wreck of the Home on the beach, comprising one of her sides and the forward body, the point where the greatest bending was represented as having been seen, and, to my surprise, I was unable to detect the slightest opening or defect in the seams or butts of the outside planking; not even to the slightest crack or opening in the coat of paint with which they were covered. On the contrary, these seams all appeared in as perfect condition as when the vessel was on the stocks.

I have forborne to mention that from *all* the testimony it was quite apparent that the behavior of the Home, as a sea-boat, was entitled to great admiration; and that, as compared with that of another steamer of acknowledged good qualities, which was then on the same coast, but had passed the shoals before the crisis of the gale, or as with that of the British ships as reported by their passengers, the Home would be found greatly superior to any of these vessels.

I have been thus particular in the above examination, because of the highly injurious effects which the current misapprehensions of this case have occasioned to our steam marine; and I now pass to the case of the Savannah, which was recently lost in circumstances mainly like those of the Home.

The steamer Savannah was built in 1838, by one of the best build-

ing firms in the city of New York, for and under the superintendence of Capt. Cobb of the Liverpool packet trade. Her length, 160 feet, was a little less than eight times her breadth; and she was in all respects a sufficiently stout and well-built vessel, constructed ostensibly for the Liverpool trade, but really for a coast steamer. In 1839 she was sent to Savannah, and was employed on the coast route, between that city, St. Augustine and Charleston. Returning to New York, she was next sent to the Gulf of Mexico, and was employed in 1840 between New Orleans and Galveston, in Texas, where she encountered much rough weather Returning again to New York, she was refitted, and sailed once more for the Gulf of Mexico, in November 1841, with a large supply of coal, and encountered a gale from N. E. when northward of Cape Hatteras. Having made the land of the Cape during the gale, the steamer was headed off shore between east and south-east, in order to weather the shoals, in a bad sea. In this situation, without any visible straining, the vessel behaving nobly, shipping no seas except in sprays, and so steady and easy that a water-cask on her forward deck was left unlashed, being only chocked by sticks of common fire-wood, the steamer sprung a leak; which increased so rapidly in spite of the engine pumps, that the fires became extinguished, and the crew and passengers finally took to the boats, the gale having at this time chiefly abated.

Capt. Crane, who commanded the Savannah, is an experienced seaman, and had navigated the British steamer City of Kingston, from Baltimore to England—she having gone from the West Indies to Baltimore for repairs. He had also navigated the small iron steamer R. F. Stockton across the Atlantic. Capt. C. describes the Savannah as being greatly superior to the City of Kingston, as a sea-boat; and behaving as above in a gale not of the greatest severity, but with almost the worst sea he had encountered. His confidence in the sea-going qualities of American steamers is not in any degree lessened by this disaster, and he seems to prefer these as sea-boats to any other vessels. He ascribes the loss of the Savannah, conjecturally, to the dislocation or fracture of one of the large discharging pipes which communicated from the engine through her bottom; and this opinion is probably correct. This appears also to be the only probable solution of the loss of the Home. It is known to many that the Home, Savannah and other steam vessels of that period were fitted, most unfortunately, with discharging pipes of *cast-iron*—an undoubted oversight which renders the above conjecture sufficiently probable.

My confidence in the strength and general sea-worthiness of these classes of American steam vessels, therefore, remains wholly unshaken; and I shall greatly deplore if the march of improvement be turned backward, and the essential interests and security of our country be compromitted, in the vain hope of avoiding liability to the accidents and dangers of the sea, by means of an unavoidable weight and solidity of construction.

There are considerations, also, which show that the available strength of a vessel of large dimensions, *cannot* be increased in propor-

tion to the thickness and weight which may be added to the planks, timbers, and fastenings; and that all such additions, beyond certain limits, contribute, in an increased ratio, to the actual strain and consequent insecurity of the vessel in a heavy sea. This difficulty is increase by the fact, that in the common methods of construction only a small part of the material employed is made fully available for strength. As most of the fastenings when the vessel labors in a sea receive the strain *laterally*, in the direction which affords the least effectual resistance, and as the small surface of the metallic fastenings have their fixed bearings only upon the softer wood which encloses them, they are necessarily pressed into the latter when subjected to a violent strain, and the seams thus become loosened; the greater portion of the entire mass of timber and planking performing little or no actual service in maintaining the original tightness and integrity of the structure.

It is for this reason that iron vessels have been found so much lighter and more buoyant than those of timber, for, excepting the loss which results from riveting, nearly the whole strength of the iron plates is made available. The loss which is here excepted probably does not exceed one-third—leaving unimpaired and available two-thirds of the orignal strength of the iron. But, from the more unyielding nature of this material, and from unequal and reciprocating strains at some of the points of junction, which may necessarily result from the elastic movements of the vessel in a sea-way, the use of iron vessels seems to be attended with some degree of danger.*

It is probably better, therefore, to adopt a plan of construction by which the strength of the planking and timbers is rendered more completely available, and by which the strain of the vessel in a rough sea-way is confined almost entirely to the woody fibre, thus relieving the metallic fastenings, which, instead of being loosened in their bearings by the heavy lateral strains they commonly endure, will have little other duty than that of confining every part in its own place, by their longitudinal and most available strength. But before explaining this method I beg leave to ask the attention of the Commissioners to the following extract from a communication in the Nautical Magazine:—

"As to the strength of iron steam vessels to those of wood, as compared with weight, we shall find the advantage greatly in favor of wood. In the experiments of Rennie, Smeaton, and Barlow, it will be found that dry fir, as compared with iron, weight for weight, is about 9 times as strong in direct tension, 7 times in direct thrust, and 6 times in the transverse or lateral strain. In other words, a bar of wood say ten feet long, of the same weight as a bar of iron of the same length, and one inch square, will carry nine times the weight of the iron bar; will bear seven times the weight in direct thrust; and six times the transverse strain. The strength of teak, oak, and some other hard woods, is not equal to fir, but three or four times greater than iron." "The true principles of naval architecture," as this writer justly says, "*are exemplified in using the exact quantity of*

* *Vide* the case of the Nemesis in doubling South Africa, and the foundering of an iron steamer in the German Ocean.

material, and no more than is necessary for the purpose required." *Naut. Mag.* 1838, vol. iv, p. 256.

It is found that some of the lighter American steamers have a draft of water not exceeding that of the iron steamers constructed in England with so much care for the service in China: while in speed and other efficient qualities they greatly exceed the latter. It appears, then, that if my object of rendering available the chief strength of the wood employed can be obtained, we may possess wood-built steamers with perhaps equal lightness of draft with those of iron, and of greatly superior strength and safety.

In the plan of construction which I recommend, we increase the moulded dimensions of the frames, but reduce the sided dimensions in an equal or greater proportion; the whole moulded surface of the frames being also smoothly planed and well and securely fitted, by screw bolting, etc. In putting on the planks, each plank is first carefully fitted to its place, and then is *checked in* to the depth of half an inch or more, upon, or over, the several frames which it crosses, and is driven on, so as to bind very tightly upon each of the several frames. At the points where the butts of the planks meet, a scarf is formed of length sufficient to rest on these frames, of which the central one, by means of the excavated check, forms a key or fid, holding the two planks fast together longitudinally. When three or four continuous strakes have been thus laid on, the next succeeding one is checked *into, instead of over, the frames,* to the same depth as the previous overlocking: thus bringing the inner surface of the planks in line with each other, and securing them against the caulking strain and torsion of the vessel. When this strake is laid on, the *overlocking* is repeated as before, and so on, alternately, from the keel to the deck. The ceiling planks, in the light classes of steamers, should be entirely omitted—as a saving of weight, a security against unobserved leakage, and to insure the greater durability and strength of the main planking and frames; but any strength which the ceiling might have afforded is to be more than compensated by a system of strong diagonals, which are also to be interchecked or locked upon each other, and also all over the frames which they are made to cross, and are to be secured to each frame with screw-bolts in the strongest manner.

This plan of construction I adopted practically in 1835; and it has also been partially adopted in the construction of Cunard's steamers—which have thick strakes interchecked upon the frames, at intervals, on which great reliance appears to have been placed. The sketches Plate 1 may show more clearly the manner in which the checking or interlocking is effected. In heavy and close framed ships, however, the checking can be best effected by moulding the alternate frames, with an alternate outward and inward projection of their sided surfaces to the extent required for this purpose.

It has been a very common, and sometimes, fatal mistake, to endeavor to obtain buoyancy and lightness of draft in a steamer by *increasing the proportionate breadth.* Of this error there have been some notable examples in the New York navigation and elsewhere, by means of which several highly respectable enterprises have been

broken up, or greatly limited in their success. However plausible the idea may appear, it is evidently founded on a false principle of construction, as may be easily shown; and it should never be attempted in practice. If greater floatage or buoyancy is desired than can be afforded by a steamer of the dimensions, and having its floor frame properly extended, it should be obtained by adding to the *length* of the midship body of the vessel, rather than to the width, and by a reduction of *unavailable* weight in the several parts. By this means any given addition to the weight and measured tonnage of the vessel, within practicable limits, will afford greater flotation, and with less diminution of effective strength and speed than can be attained by like additions of weight and tonnage when made to the *breadth* of the vessel.

I have now to offer some remarks on a better adaptation of the light classes of steamers to the objects of the naval service.

1st. The proportion of length to breadth in these steamers should never be less than the average of class C—the length being equal to *nine breadths* or *diameters;* and, if extended to nine and a half, or even ten diameters, this will perhaps be within the limits of maximum advantage. These ratios of length are especially required for objects yet to be noticed. The proportion of *depth*, however, may be slightly increased, if sufficient care be taken to restrict the top weight.

2d. The extreme horizontal outline of the deck and guards should be brought *within* an angle of fourteen degrees from the midship line at the bow and stern; in order not only to ease of motion, but to favor the deflection of the shot of an enemy from the hull when engaged *head or stern on.* The bow and stern angles at the water line will necessarily be much finer—say within the semi-angle of eight or ten degrees. The stem and stern post should be nearly vertical, and the floor frames, or at least their rudimentary forms, should be extended forward and aft to the joinings of the stem and stern post; dispensing altogether with the common "dead wood" of the stern. Suitable provision should also be made for steering in opposite directions, with either stem or stern foremast.

3d. The deck frame should consist of plank-sawed and deep-moulded scantlings, one to each frame of the vessel, and screw-bolted to the same in crossing to the guard or fender line. The common deck knees should be dispensed with, and snug knees of hackmatack be applied externally, at proper intervals, where the projection of the guards will permit.

4th. There should be a very light hurricane-deck over the central portions of the hull, and extending to a length equal to two or three diameters of the vessel. All the constructions above deck should be of the very lightest description, and be comprised, if possible, within the same limit. Thus the forward and after ends, each to the extent of about three diameters of the vessel, would be left free of incumbrances; excepting the gun-fixtures and other indispensable attachments.

5th. The engine should be so placed below deck as to act directly upon the cranks, as in the steam frigate Missouri, if the midship body

of the vessel will allow of this arrangement; otherwise, a half-beam arrangement may be resorted to. The paddle-wheels should spread less on the shaft than is common in American steamers, and the paddle be extended to a point at its centre in a trapezoidal or triangular form. This form will admit of a greater immersion, and thus obtain a better resistance, than the common paddles, especially in a sea-way. The crank and chimney openings in the deck should be comprised in a narrow enclosure, with upright sides, extending fore-and-aft-wise to a point so as to present an acute angle of deflection, for the protection of the crank and lower part of the chimney from shot when *end on* with an enemy. The main shafts, which must be above the deck, should also be protected by *deflecting planes* covered with iron and slightly inclined from horizontal.

Much apprehension has been sometimes manifested for the safety of the wheels and paddles when under fire; but those who have employed steamers day after day, for successive seasons, in encountering ice from four to fourteen inches in thickness, and who have witnessed the speed of a steam vessel when one half or more of the wheel arms and paddles have been disabled in this service, will think more lightly of this hazard; to avoid which, almost every quality valuable for a war steamer has sometimes been sacrificed.

6th. To sustain the guns, the scantlings beneath them should be somewhat enlarged in thickness, and securely stanchioned and screw bolted. The gun pivots should be of strong timber, adequately secured to the deck-frame, and extending to the keelsons. The deck, where exposed to the action of the guns, should be strongly sheathed, and the whole be secured, if needful, by transverse bars, strongly bolted or clamped to the deck-frame; and, if necessary, connected by vertical bolts and stanchions with the floor-timber. When about to engage, sand bags, or other equivalent weights, may also be used for covering that portion of the deck exposed to injury from the explosion of the guns.

To illustrate my views of the proper form of construction of these vessels, I annex an approximate sketch or outline of the deck plan and guards. This outline has, for its base, the elongated rhomb a, a, b, b, fig. 3, and presents at the deck a guard line of the bow and stern, a, a, the maximum semi-angle of fourteen degrees; which is only equal to that which has been already adopted in some well proportioned steamers for coast service. It also contemplates a length which is equal to nine diameters of the vessel; each of these diameters being visibly set off on the plan. It will be found practically, that this proportion of length is sufficiently limited; for the engine, if placed as proposed, will require much length, and the necessary weight must, also, for a light draft, be extensively distributed. Moreover, the first diameter at each extremity, the flotation of which can properly support little more than itself, may be viewed as substituted for the cutwater, bowsprit and other fixture, which is commonly attached to heavy steamers and sailing vessels; while the second diameter thus set off, answers practically to the usual bow and stern in other vessels; thus leaving five diameters for the proper body of the vessel and the necessary machinery and storage.

7th. The armament of each steamer, I apprehend, should consist of *six traversing guns.* Two of these, of ten inches calibre, should be worked each on a strong pivot, placed on the line of the keel, at the distance severally of about one and a half or two diameters of the vessel from the stem and stern post. The four remaining guns, each of eight inches calibre, may be worked on like pivots, placed near the sides of the vessel, and as much nearer to the main shafts as will avoid interference with the two larger guns. When engaged with an enemy, *the line of fire should always, when practicable, be in the line of the keel.*

The above mentioned ordnance constitutes the armament of the recently constructed war steamers of England; and, so far as I can perceive, is the most appropriate and effective for a steam vessel: the peculiar vocation and advantages of which ought to be rapid motion and effective fire. In steamers of class D, or of *very* light draft, it may *possibly* be expedient to substitute 32 pounders for the four eight-inch Paixhan guns. But of the expediency of such substitution, I have strong doubts; and I hold it to be a waste of effort and resources, to arm a steamer or a ship for warfare at this day with ordnance of common weight and quality, or which is in any respect inferior to the heaviest and best which an enemy can present. Besides, the *lightest* steamer employed by us in war should be furnished with artillery suited for combat with the heaviest and most powerful ship afloat.

Perhaps some persons may entertain apprehensions of the inability of these light steam vessels to carry and sustain the action of the guns above mentioned. But these apprehensions are without any just foundations, as will appear from the following facts and considerations:

(1.) The points at which the guns are placed, require an access of weight equal to this armament, in order properly to equalize the load throughout the body of the vessel.

(2.) The weight merely of these guns is no more formidable or destructive to a vessel than a like concentrated weight of other heavy articles, of which vastly greater amounts are safely carried in all weathers on lighter decks than I propose for these vessels.

(3.) Owing to their large capacity, and their great superficial bearing upon the water, these vessels are better able to bear the addition of the above weight than any vessels now in the naval service. This may appear from the following facts: 1st, The average load-line area, or bearing superficies, of class C in the table, is nearly *three fifths* of that of the Brandywine frigate; while, if we allow 50,000 lbs. for the guns and carriages of the steam vessel, and 48,000 lbs. for the ammunition and other accessaries, it will then equal but *one-fifth* of the weight of the armament and its accessories of the Brandywine; and will require to sustain it only a draft of four and a half inches from the light load-line. Again, this average superficial bearing of the steam vessels is more than *four-ninths* that of the Ohio ship of the line: while the above weight of guns, ammunition, etc., is less than *one-eleventh* the weight of the military outfit of the Ohio. Once more, the average height of the *decks* of these steamers above the water at midships, exceeds *six feet*, with an average bearing surface

of near *seven and a half feet per ton* of the vessel and its contents. (See lines 12 and 30 of the table.) While the height of the port-sills of the Brandywine and Ohio are but *five and a half feet* above water, with an average bearing superficies of nearly *two and a half feet per ton.*

This shows an immense proportion in favor of these steamers, in the ability to carry accessory weight. Hence, this class of steamers may not only carry this armament, but, in addition, may also transport, when occasion requires, from five to eight hundred troops.

It may be well to notice here the apparent chances of this class of steam vessels when opposed to heavy war ships of the rates above mentioned.

1. *The choice of action* and position will always belong to the steamers. This is important when opposed to any force whatever; for the most favorable time and circumstances for combat may thus be commanded, or, if it should be proper and advantageous, the action may for the time be easily avoided. While, on the other hand, an equal or inferior force need not be allowed to escape.

2. *The target surface* presented by the Ohio when in chase, below the hammock rails, is probably equal to 1450 square feet; and in broadside about 5600 square feet. The cross area of the Brandywine presented in chase is probably equal to 940 feet, and that of her broadside area near 3800 feet; while the average cross area of the hulls of the steamers of class C exposed above water, to a height of seven feet above the deck, is only *three hundred and forty feet.* Now, as the steamers will probably engage chiefly at long shot, and *end on*, we may here perceive how great will be the advantage for the steamers, with equal skill in gunnery, whether or not a sufficient number of steamers to match the broadsides in weight, be taken into the account.

I say nothing here of the extraneous exposure of the wheels and smoke-pipes on one hand, nor of the spars and rigging of the ships on the other: believing that these chances, with proper precautions, are not unfavorable to the steamers.

3. From the great stability and superior steadiness of these steamers when in motion, particularly on the line of the keel, and from the accuracy with which they may be made to head *on or off* an object, by means of a marking point subtended above the bow, to guide the helmsman, they will afford to skilful gunners greater accuracy of fire than is usually obtained in ships, unless the latter be lying in smooth water.

4. In comparing the weight of metal opposed, if we reckon to the steamers the full weight which is due to the increased calibre of their guns, (and considering the greater destructiveness of shells to a ship, this appears not improper,) we shall find that four of these steamers, each with three guns engaged, will exceed, at each round, the weight of shot thrown by the broadside of the Brandywine; and that the fire of seven steamers will equal, in like manner, the broadside of the Ohio. While, in *chase*, there would be an overwhelming advantage in favor of the steamers.*

* In these estimates the weight of shot thrown by the broadside of the Ohio is

5. As regards the relative power of endurance, if shells are used, as they doubtless will be, this power in a vessel cannot be in proportion to the weight and massiveness of the structure; and may prove quite the contrary. But, if the form of model and position in action, which is here recommended, can be made efficacious in some degree for the protection of the engine and boilers below deck, which seems practicable, the steamers, with equal gunnery, must clearly have greater advantages for the endurance of fire in the aggregate than will belong to the ships. Besides, if we may estimate the aggregate power of endurance to be in proportion to the bearing area or superficial extent of the vessels, as appears not wholly improper, this advantage will be proportionally in favor of the steamers. Moreover, in shell-firing a single shot may prove fatal to a ship; while even a like result to one or more of its alert antagonists need not cause a discontinuance of the combat.

It might also have been suggested above, that as between ships and steam vessels the chances of the former rest only between victory and surrender; while with the latter they will ordinarily lie between victory and an easy escape. The chances, also, as between these active classes of steam vessels and the heavy steamers, or the broad and slow moving light steamers of an enemy, will partake much of the same character.

I propose now to notice the importance and necessity of the light and active classes of steam vessels for the naval service, and the purposes of national defence.

It has been well remarked by our naval historian, that "the first great object of the government should be to prevent blockades—its next, to employ vessels that cannot be blockaded."

However important it may be to maintain a powerful and well ordered navy, consisting of ships of the established classes, it can hardly be in our power, or within the scope of our policy, to maintain a numerical superiority as against England, even on our own coasts. And without such superiority, or at least a near equality, effectual blockades may not hereafter be prevented; to say nothing here of the chances of losing our ships and naval arsenals, by the onset of a powerful and well appointed expedition, supported by a numerous fleet of ships and war steamers.

With the aid of her numerous and heavy armed steam ships, England might effectually blockade not only our ships, but our war steamers of the heavy and medium classes. For our steamers of these classes could hardly put to sea, or return to port, in the face of a superior force of the same character; and it would be quite in vain to attempt gaining a superiority of this force by new constructions of like kind, for the present means of England, both mechanical and financial, are sufficient to outdo us in this effort, more than three to one. It is therefore indispensable to our superiority, that we should be prepared *with faster steamers, of lighter draft, and equal weight of metal, with those of England.* These steamers, being of the

taken at 1600 lbs., and that of the Brandywine at 864 lbs., as by advisement; and the shot of the eight and ten inch guns at 68 lbs. and 98 lbs. respectively.

classes which I propose, could never be blockaded in our ports by the existing naval means of any country. Moreover, if maintained in sufficient numbers, so as to be readily assembled in large squadrons at the points where the exigencies or demands of the service might require, the most powerful fleets would be unable to maintain a blockade, or to carry out with success a military expedition against our shores.

The same classes of steamers are also of essential importance on our frontier lakes, where armed steamers of the heavy classes and draft of water hitherto adopted, would be of greatly inferior value; and where all the strategetical advantages will be in favor of the classes proposed.

The greater value and adaptation of light built steam vessels, tenaciously constructed—not less in length and size, nor exceeding in weight and draft, the average of the classes C and D, may be now reviewed, or more summarily considered.*

I. Their facility of movement and surpassing speed, exceeding that of existing war steamers from three to six miles an hour, must necessarily afford, as above mentioned, the choice of action and position; and, excepting accidents, no enemy can either escape or overtake them, except at the will of their commanders.

II. Owing to the light draft of water and greater speed of these vessels, they may shelter themselves from a superior force in shoal positions, or attack and annoy the enemy from such positions on a vast extent of coast and inner waters, where heavy ships or steamers cannot approach. When the elaborate survey of our coast, now in progress, shall have been completed, and our officers shall also have become familiar with these shallow grounds by active coast service, in proper steam vessels, these facilities may become of great value.

The shoal inlets, bays and lagoons, of our sandy coast, from Nantucket to Texas, afford not only shelter but inexhaustible supplies of fuel for these steamers; and not only may these shores be thus protected from the assaults and incursions of an enemy, but regular cruisers may be constantly maintained from these inlets, by alternate portions of the squadrons thus assigned to the various points of our coast or the annoyance and capture of an enemy's navy or commerce.

III. By this means, not only may the exposed positions at Key West and other points be maintained in war, and made available for the annoyance of an enemy, but the strait of Florida, if not the other outlets of the Caribbean Sea and Gulf of Mexico, may be effectually and securely blockaded by squadrons of these steamers.

To illustrate this point more particularly, I beg leave to refer the Commissioners to the charts which are annexed.

It will be seen on the charts, that large portions of the Bahama Banks and other shoal grounds comprehending many hundred square miles, near the Florida strait, the Providence channel and elsewhere afford a depth of water which is barely sufficient for the navigation of these steamers, and will effectually exclude the heavier classes.

* I consider the Gladiator as being the proper type of the class D; except as being slightly deficient in length, which would be better at 200 feet.

This is particularly seen near Gun Cay light, and on the Florida reefs; where a squadron of these steamers may act securely, and attack or pick up everything that attempts to pass the strait of Florida, which can here be crossed by the steamers in about four hours. Nor is it seen how any existing naval force could dislodge such squadrons from these positions; from whence they might successfully assail not only the general commerce of the enemy, but his war steamers and other forces. Many secure positions are doubtless to be found on the opposite Florida reefs, and the banks not yet surveyed, as well as in some other parts of the West Indian Archipelago; while the coasts and inlets of Florida will afford supplies of fuel to any extent which may be desired. It is hoped that the enterprising officers, engaged in suppressing Indian hostilities, have well explored and noted the needful positions for these objects.

IV. By means of these active steam vessels, and a suitable and skillful force of Marines and Marine Artillery, trained for both land and sea service, which, I trust, may shortly be provided, an enemy's colonial posts may be captured, and his military resources laid under contribution. By like means, in case of a war with England, might the coal furnishing ports, and other outposts near our eastern frontier, be taken into our possession, and retained, or abandoned, as occasion might require.

V. It is chiefly by these means that we may expect to command, in such emergency, the more hazardous coasts of Maine, Nova Scotia, and the Gulf of St. Lawrence; thus cutting off the communications and military supplies of an enemy, and virtually blockading his American Colonies. On these rocky coasts, as elsewhere, any general degree of safety which might be supposed to result from solid built bottoms and heavy structures, may be far more than compensated by lightness of draft and tenacity of structure, and facility of movement; while in security against attack from a superior steam force, the heavy built steam vessels could maintain no equality with the light footed classes. The coast of Maine affords all necessary shelter and resources for this service; and this description of force, if matured by timely preparation, and put forth in our strength, might generally command the coasts and shores, from Quebec to Nantucket. Two or three vessels of the proposed class would doubtless prove more than a match for one of the heaviest English steam ships; and, for reasons already noted, the latter might find it difficult to escape.

VI. By proper arrangements, and, if needful, with the associated aid of one of the steam frigates, these lighter built steamers may be sent to any part of the world, where their services may be desired, and where friendly or neutral ports can be found to afford the necessary shelter and supplies of fuel. Their great speed and efficiency might thus be employed with great effect on an enemy's commerce and resources.

I have been led, by the request of the Commissioners, thus to explain, to some extent, my views on this essential branch of public defence, and to urge the adoption of a class of measures on which I consider the future safety of the country may largely depend; being ful

ly persuaded that it is not so much on the *magnitude*, as on the *available qualities* of our naval force, that we must rely for success in any future conflict with the great mistress of the seas.

I am, sir, with high respect,
Your obedient servant,

New York, January 25, 1842. WM. C. REDFIELD.

REFERENCE TO PLATE 1.

Fig. 1.—Cross section of steamer near midships. *c*,—Bilge strake. *d*,—Engine bed. *e*,—Floor timber. *f*,—Keel. *g*,—Top timber. *h*,—Deck beam or carline. *i*,—Sponsing, if wanted.
Fig. 2.—Outside planking.
Fig. 3.—Section at *bb*, showing diagonal and interior side. *k*,—Deck plank. *l*,—Section of deck beam or carline. *m*,—Inside clamp. *n*,—Diagonal braces.
Fig. 4.—Keelson and floor timber longitudinal section at *a*. *o*,—Section of keelson. *p*,—Section of floor timber. *r*,—Bottom plank.
Fig. 5.—Profile and view of a light war steamer. 6,—Deck plan. 7,—Water line.

Extracts from the Report of NAPOLEON GARELLA, *an Engineer appointed by the French Government to survey the Isthmus of Panama. Translated for the Journal of the Franklin Institute by* PERSIFOR FRAZER, ESQ.

Topographical Configuration of the Isthmus of Panama.

This remarkable isthmus, which, uniting the two Americas, extends between the Gulf of Mexico and the Pacific Ocean, to a length of 2300 kilometres, (1430 miles,) in a direction from W. N. W. to E. S. E., presents along this enormous length a variable width. From the mouth of the Guazacoalco, its point of junction with North America, where it has a width of 220 kilometres, (137 miles,) it continues narrowing regularly enough, with the exception of the two large promontories of Yucatan and Central America, to its other extremity, towards the Gulf of Darien, where it is united to South America. It is towards this last portion, where it is called more particularly the Isthmus of Panama, that it attains its minimum width. From the town of Panama to Chagres, the distance in a straight line is but 65,470 metres, (40·68 miles:) from the mouth of the Caimito, on the Pacific Ocean, 22,000 metres, (13·68 miles:) west of Panama, to the embouchure of the Chagres on the Atlantic, the distance is but 58 kilometres, (36 miles;) but the minimum width appears to be a little more to the eastward, between the bay of Mandingo or San Blas, on the Caribbean sea, and the shore of the Pacific Ocean, near the embouchure of the Rio Chepo, where the distance, according to the map, is but 50 kilometres, (31·07 miles.) The chain of mountains which extends in a direction nearly north and south, the whole length of the two Americas, from the icy seas of the north pole, to Cape Horn, presents along nearly its whole length of 14,000 kilometres, (8700 miles,) a considerable elevation. Its peaks are only surpassed in height by the summits of the highest of the Himalayas, and even its vast plateaux have an elevation superior to that of the highest mountains of the interior of France. This chain extends, without any discontinuity, the whole length of the isthmus, but then as the breadth of the land diminishes, so the ridge of the chain sinks considerably, and presents some depressions, whose height above the ocean is less than that overcome by some of the European canals already con-

Fig. 5.

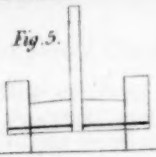


Fig. 4.

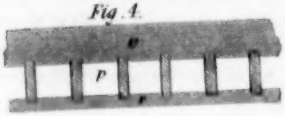


Fig. 2.

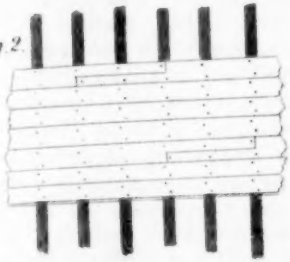


Fig. 3.

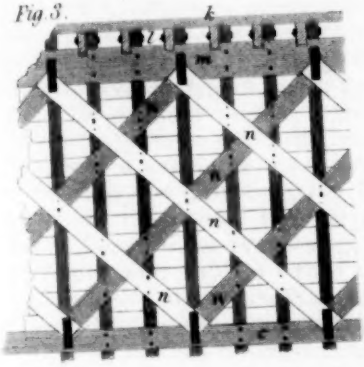


Fig. 6.

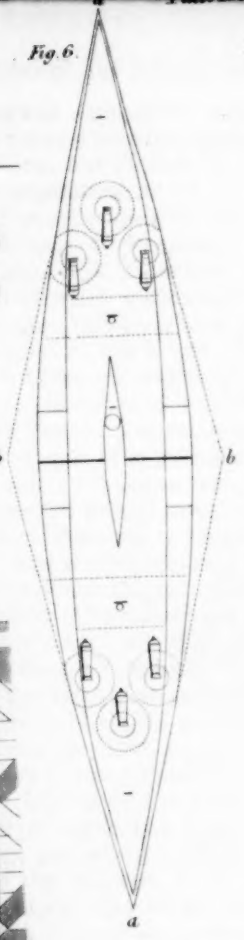


Fig 7

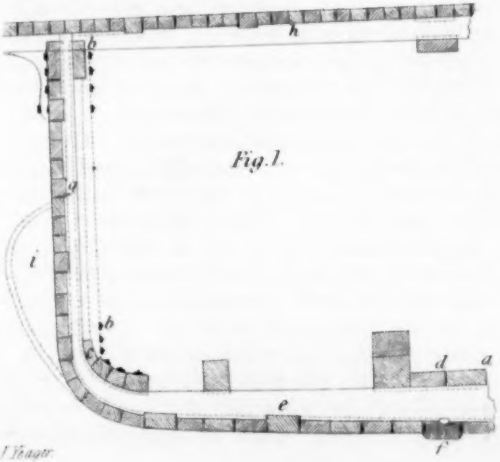


Fig. 1.

Eng. by J. Yeager.

structed. One of these remarkable depressions exists in the neighborhood of Panama—not at the point where the isthmus is narrowest, but a little to the westward, where, however, it is narrower than at Panama. In examining the configuration of the isthmus from west to east, it will be remarked that, passing from the state of Costa Rica (Central America,) into the province of Veraqua, (New Granada,) under the 85th degree of west longitude, 3 degrees to the westward of Panama, the central ridge dividing the waters flowing into the two oceans, retains a considerable height, relatively at least to the narrowness of its base; that it is continued at this height for a considerable distance; and that it appears to break off suddenly at the steep and precipitous peaks of the Trinity, (Cerro de la Trinidad,) situated 50 kilometres (31·07 miles) west of Panama, whose height may be estimated at from 12 to 15 hundred metres, (4 to 5 thousand feet.) There commences the depression of which I have spoken, and which extends a distance of 40,000 metres, (25 miles,) to the hills of Ormigueros, not far from the roads from Panama to Couces and Gorgona. The ridge then rises by degrees, and attains, opposite Porto Bello, and near the Gulf of San Blas, its previous height. Along this distance there are a number of points whose elevation varies from 130 to 160 metres, (425 to 525 feet,) between which the ridge rises but little, and forms hillocks, and not peaks or elevated masses. This depression of the central chain is, then, one of the first and most evident observations which the explorer makes; and it has been noticed by nearly all those who have surveyed the isthmus; Mr. Lloyd points it out for the line of a canal; and it is there, also, that Mr. Morel, the agent of the Salomon Company, has laid down his route. It is evidently there that the summit level of the maritime communication to be opened between the two oceans, should be placed. Unfortunately, those who have hitherto visited the isthmus, have only judged approximatively of the height of this portion of the chain, and that by a simple visual observation, made without employing any instrument, and mostly at long distances; and taking, without doubt, as points of comparison, the elevated mountains of the Trinity, and other masses of a considerable elevation, situated more to the eastward; those of the Cerro Cabra, which are 492 metres (1614 feet) high, and those of the Cerro Grande of Gorgona, which rise to a height of 310 metres, (1017 feet.) Thence, doubtlessly, comes the erroneous opinion spread abroad, on the faith of some navigators, that the central chain uniting the elevated table land of Mexico with the Andes of Peru, ceases entirely in the portion of the country of which we are now speaking; and is cut by a transversal valley, where man will have almost nothing to do to establish a navigable communication between the two oceans. Thence, also, without doubt, the extraordinary assertion advanced by the Salomon Company, that this depression of the chain offers a point of passage situated only 11·28 metres (37 feet) above the mean height of the sea at Panama, a point which the company naturally chose for carrying across the summit level of the canal which they projected. From the sides of the Cerro de la Trinidad flow three principal streams, of which the most important, the Caimi-

to, running at first parallel to the central chain from S. W. to N. E., turns at length to the right, towards the S. E., then towards the S., and empties itself into the Pacific, not far from the village of La Chorrera, 22 kilometres (14 miles) west of Panama, after having received as its principal tributary, the Bernardino. The two other streams, which flow towards the Atlantic, are the Caño Quebrado and the Rio Trinidad—rising at nearly the same point, they separate as they advance; the first flows parallel to the central chain and to the Caimito—the second runs nearly due north; they both empty themselves into the Rio Chagres, which descends from the elevated mountains situated to the east of the line joining Panama and Porto Bello, and flowing at first towards the south-west and west, at length turns towards the north-west, a little before receiving the Caño Quebrado, and empties itself into the Atlantic at the Port of Chagres, 27 kilometres (17 miles) below the junction of the Rio Trinidad. The Rio Trinidad has its mouth 15,000 metres (9·23 miles) in a straight line below that of the Caño Quebrado, and in the triangular space comprised between the two streams, the laws of nature, which, throughout America, have placed the ridge of separation of the waters flowing into the two oceans, nearer the western side, appears to have been maintained. The spur, in general of slight elevation, which separates the basin of the Trinidad from those of the Caño Quebrado and the Chagres, extends uniformly along the two last rivers, the effect of which is to augment considerably the former at the expense of the Caño Quebrado, which, consequently, is the channel of a much less considerable volume of water. The wide space which separates the bed of the Trinidad from the base of the spur, is occupied by vast and, for the most part, unbroken plains, from the middle of which rise some isolated hillocks. One does not there meet with the water courses which might be expected from their extent, but many swamps, and even deep lakes, communicating with the Rio Trinidad by small natural canals, called *esteros*. In these plains is found the large lake of *Vino tinto*, observed by Mr. Morel, which is upwards of a league in diameter. Here also are found, near the mouth of the river, the swamps of *Agua Clara*, which have in some places, as I have been assured, a depth of water of 12 metres (42·65 feet.)

Besides these streams, there is another on the western slope, flowing directly into the Pacific; it is the Rio Grande, situated between the Caimito and Panama, and having its mouth 2,000 metres (1¼ miles) west of that city. It is indeed a stream of no great magnitude, the upper portions of which are completely dry during some months of the year; but it presents a characteristic which it has in common with other affluents of the Pacific Ocean, which is, that the lower portion of its bed has but a slight descent and great width, so that the tide mounts it to a considerable distance, and thus forms an arm of the sea (estero) intruding into the land, with a depth varying from 8 to 10 metres, (25 to 33 feet,) and sometimes even more, which offers facilities for navigation, though only during high water, and as far as the tide flows. It is to this characteristic that the Rio Grande owes its name, though in fact it is but a brook. Along side of the Rio

Grande is another little ravine, pouring its waters directly into the sea. This is the Rio Farfan, having, towards its mouth, a wide and deep bed, which, at this point, is only separated from the Rio Grande by a hill, around which its waters are forced by high tides, flowing into the Alvine marshes, through which the road from Panama to Chorrera passes, thus mingling the waters of the two creeks.

This feature of a great diminution of fall near the embouchure of the stream, is still more perceptible on the Atlantic slope. The Chagres, which is undoubtedly the most important and most voluminous stream of water of this portion of the isthmus, presents it in a very striking manner. The tide of the Atlantic, which rises but from 34 to 40 centimetres, (13·38 to 15·75 inches,) ascends the river a distance of 28 kilometres (17·40 miles) from its mouth, above the point where it receives the Rio Trinidad. The Rio Chagres, according to a gauging made at Gorgona the 26th of March, 1844, at the period of the lowest water, above the Caño Quebrado and the Rio Trinidad, pours a minimum volume of water of 19 ·50 cub. m. (688·69 cubic feet) per second. In the lower part it is to all intents an arm of the sea; the current sometimes ascending, sometimes descending, is very feeble. Its width varies from 60 to 100 metres, (65 to 110 yards,) and the depth, which averages from 4 to 5 metres, (13 to 16½ feet,) increases at some points to 10 and 12 (32 and 40 feet.) This river, then, is navigable; but, nevertheless, with some difficulty beyond a distance of 30 kilometres (18·64 miles) from its mouth. Thence it can be ascended only by poling, on account of the rapidity of the current and the irregularity of the bottom. Laden boats ascend it as far as Gorgona and Crucés, but in the dry season (from December to June) they are obliged to unload the larger barques on a beach near the mouth of the Caño Quebrado, and to load again in smaller boats; and even with these they have great difficulty in reaching Crucés. In the rainy season, when the depth is sufficient, the current becomes so rapid that the ascent is made but slowly, and requires from 8 to 10 days for a distance of less than 80 kilometres, (49·70 miles.) With the exception of the Rio Chagres, the other rivers of the isthmus can hardly be said to be navigable. The Rio Trinidad above the point which the tide reaches, is but a rapid brook, (*ruisseau torrentill*,) which can be ascended a certain distance only when it is swollen by the rains, and then with great difficulty. The Caimito presents a great depth of water only in the vicinity of its mouth, and it is not possible to ascend either it or the Bernardino further than, or without the assistance of, the tide. It appears to me, then, that none of these water courses can be made useful for the purposes of navigation, except as far as the tide flows; and, moreover, in that case, there would be necessary, at least on the Pacific side, constructions for the especial purpose of confining the water and preventing the effects of the rise and fall of the tide, which is here very great.

At Panama, from observations made during my residence, the highest tides of the full and new moon of the equinox (6th and 21st of March, 1844,) are 6.10 m., (20 feet;) the lowest neap tides are 2 .75 m. (9·02 feet.) On the Atlantic they are but 35 to 40 centime-

tres, (13·38 to 15·75 inches.) This last variation in the level of the water is too trifling to be taken into account in the execution of a canal of communication, otherwise than in adopting the level of the lowest tides as the point of departure for the depth to be given to the canal.

The waters flowing from the central chain, at its point of depression, are divided, as we have seen, between two basins: that of the Caimito upon the Pacific slope, and that of the Rio Chagres, or rather of the Caño Quebrado, upon the Atlantic slope. I do not take into account that of the Rio Trinidad, because its sources, which are very close to the Cerro Trinidad, appear to be at too great a height to authorise us to seek there a point of passage. The first of these basins, which pours its waters directly into the sea, is bounded on the west by a spur of the Cerro Trinidad, terminating in the neighborhood of the village of *La Chorrera*, by round hills of no great elevation, and plains somewhat broken, from the middle of which rises the Cerro Gordo, a conical mountain entirely isolated, of about 100 metres (328 feet) in height. On the eastern side it is separated from the basin of the Rio Grande by an elevated spur, which, running off from the central chain at the Cerro Calderon, or neighborhood of the Ormigueros, loses itself in the mass of the Cerros de Cabra, the most elevated mountains of this portion of the isthmus. Its principal tributaries are the Rio Bernardino and the Rio Aguacato, which flows into the former. The second basin, that of the Caño Quebrado, which is itself but a principal tributary of the Rio Chagres, embraces about the same extent of the central chain. It is limited on the east side by a hill forming an abutment to the ridge of the Ormigueros.

It is then between the two basins of the Caimito and the Caño Quebrado, that the point for the passage of a canal of communication between the two oceans, is to be sought. It is along their tributaries that we must look for the valleys where the canal should pass; and finally, it is in the neighborhood of the localities where their waters empty into the sea, that is, near the mouths of the Caimito and the Chagres, that we must seek the points of communication of the canal itself with the two oceans; the bars which always form at the points where the running waters of rivers meet the still waters of the ocean, rendering it necessary, as a general rule, to avoid carrying a great line of navigation to those points.

The Rio Chagres has, in fact, at its mouth, a bar with a depth of water of but 4 metres, (13·12 feet,) much less than that found in the river itself, which cannot be passed by vessels drawing more than 3 .50 m. (11·50 feet) of water; those attaining that limit being able to pass it with difficulty, and only in fine weather. In the middle of the bar is a rocky shoal situated but 1 metre (3·28 feet) below the surface of the water, which narrows the pass to about 200 metres, (220 yards.) This bar, abutting on the eastern side against the high rocks, on which is built the fort of San Lorenzo, and at the foot of which flows the river, is united on the west to an extensive beach, which borders the isthmus for a long distance on the Atlantic coast. Under these circumstances, the insufficiency of such an en-

trance for an oceanic canal like that of which we are treating, may be easily comprehended; a canal which should admit ships of the greatest tonnage, and demanding at the least a draft of 7 metres (23 feet) of water. Doubtlessly it would not be impossible to remedy, at least temporarily, this defect; but the uncertainty, proved by experience, of the results of operations carried on at the mouths of rivers even larger than the Chagres, especially when they are for the purpose of opposing the accumulation of sand, should induce us to employ such means only in case it should be impossible to find another suitable entrance; here, however, nature herself appears to have provided one. 8,000 metres (5 miles) to the eastward of the Rio Chagres, is the large and capacious bay of Limon, which is 4,000 metres (2½ miles) in width, and 6,000 metres (3¾ miles) long. It has a great depth of water, which, in the centre, reaches 6 brasses, or 10 metres, (32·81 feet.) This bay is separated from the river by a tract of land in general of but slight elevation, and offering some low portions, which afford facilities for excavating a canal of communication with the river; works simple and easily constructed, will suffice for the establishment of a vast and sure port at the entrance of the canal, in the bay, which, opening to the north, is at present exposed directly to the action of the north, north-east and north-west winds, which reign almost constantly in these latitudes.

These disadvantages found at the embouchure of the Rio Chagres in the Atlantic, are still more apparent at that of the Rio Caimito in the Pacific. This embouchure is situated in the middle of a vast beach, which low water leaves uncovered to a distance of about 1,000 metres (1100 yards) from the shore; it thus unites a want of depth of water and the inconvenience of sand banks; the former may be remarked on nearly the whole of the coast from Panama to the Caimito, and at that city, on account of the great rise and fall of the tides, small vessels, such as brigs, of two to three hundred tons, drawing from 3½ to 4 metres (11½ to 13 feet) of water, are obliged to anchor off at a distance of 2,000 metres, (1¼ miles.) Sand banks are also found along nearly the whole coast, but more particularly at the bottom of the bays, and at the mouths of the streams. It is especially between Panama and the Cerros de Calva, that the want of a sufficient depth of water is observable. This defect is apparent from the great number of little islets which are seen at a certain distance from the coast, and which are surrounded by rocky shoals protruding above the water at low tide—amongst others the isle of Venados, which, at high tide, is 1200 metres (1300 yards) from the shore, is united to it by a ledge of rock which low water leaves bare. The number of these islets diminishes as you advance to the westward, and they disappear altogether opposite the mouth of the Caimito, leaving entirely free the arm of the sea separating it from the islands Taboga and Taboguilla, which are situated 11 kilometres (6·83 miles) from the coast, and where the largest vessels find an excellent anchorage. The coast does not offer in this neighborhood a favorable locality for a good port, with a sufficient depth of water, for to the depth of

water necessary for vessels must be added the height of the rise and fall of the tide.

But, fortunately, the neighborhood of the port of Taboga, and the almost constant tranquility of the Gulf of Panama, at the bottom of which is the mouth of the Caimito, permit us, in establishing the entrance of the canal, to take into consideration only the depth of water at high tide.

The place on the coast which appears to me the best to correspond with the required conditions in this respect, is a little bay with an opening of 350 metres, (382 yards,) and a depth of 200 metres, (218 yards,) situated 4,000 metres (2½ miles) to the eastward of the mouth of the Caimito, at the foot of the small mountain of Vaca de Monte, and to which, therefore, I have given the name of Ensenada de Vaca de Monte; it is bordered by rocks, and there flows in at the bottom of it a little stream of very trifling volume. At its entrance the mean depth was found to be 3 metres (9·84 feet) at the low tide of the 3d of July, 1844, (three days after the full moon,) which would give at least 8 metres (26¼ feet) at high tide. There would be but little to do at this point to establish the entrance lock of the canal with such a depth of water that ships might enter, at least at high water, during the neap tides, about the first and last quarters of the moon.

(To be continued.)

Abstract or short Summary of Results from Experiments relative to the proposed Bridge across the Menai Straits, addressed to Robert Stephenson, Esq. By W. Fairbairn.

After a series of experiments undertaken at your request, for ascertaining the strongest form of a Sheet Iron Tubular Bridge across the Menai Straits, I have been induced, in order to meet the requirements for such a structure, and to ensure safety in the construction, to call in the aid and assistance of my friend Mr. Hodgkinson.

The flexible nature of the material, and the difficulties which presented themselves in retaining the lighter description of tubes in shape, gave exceedingly anomalous results; and having no formula on which dependence could be placed for the reduction of the experiments, I deemed it necessary, in a subject of such importance, to secure the co-operation of the first authority, in order to give confidence to the Chester and Holyhead Railway Company, with whom you are connected, and the public generally.

It will be observed, that the first class of experiments is upon cylindrical tubes;—the second upon those of the elliptical form;—and the last upon the rectangular kind. Tubes of each sort have been carefully tested, and the results recorded in the order in which they were made; and moreover, each specimen had direct reference to the intended Bridge, both as regards the length and thickness, as also the depth and width.

In the first class of experiments, which are those of the cylindrical form, the results are as follows:

Cylindrical Tubes.

No. of Experiments.	Distance between the supports.	Diameter in inches.	Thickness of Plate in inches.	Ultimate Deflection in inches.	Breaking weight in lbs.	Remarks.
	ft. in.					
1	17 0	12·18	·0408	·39	3,040	Crushed top.
2	17 0	12·00	·0370	·65	2,704	Ditto.
3	15 7½	12·40	·1310	1·29	11,440	Torn asunder at the bottom.
4	23 5	18·26	·0582	·56	6,400	Ditto.
5	23 5	17·68	·0631	·74	6,400	Ditto.
6	23 5	18·18	·1190	1·19	14,240	Ditto.
7	31 3¼	24·00	·0954	·63	9,760	Ditto.
8	31 3¼	24·30	·13501	·95	14,240	Ditto.
9	31 3¼	24·20	·0954	·74	10,880	Ditto.

With the exception of the first two, nearly the whole of the tubes were ruptured by tearing asunder at the bottom through the line of the rivets.

Finding the cylindrical form comparatively weak, the next experiments were upon tubes of the rectangular shape, which gave much better results. For the present it may, however, be more convenient to take the elliptical kind, as being the nearest approximation, as regards both form and strength, to the cylinders recorded above.

Elliptical Tubes.

No. of Experiments.	Distance between the supports.	Diameters, transverse and conjugate in inches.	Thickness of Plates in inches.	Ultimate Deflection in inches.	Breaking weight in lbs.	Remarks.
	ft. in.					
19	17 0	14·62 9·25	·0416	·62	2,100	Crushed on top.
20	24	21·66 13·50	1·1320	1·36	17,076	Broke by extension.
21	24 0	21·25 14·12	·0688	·45	7,270	By compression
22	18 6	12·00 7·50	·0775	·95	6,867	By compression. This tube had a fin on the top side.
24	17 6	15·00 9·75	·1430	1·39	15,000	Both sides were ruptured

It will be observed that the whole of these experiments indicated weakness on the top side of the tube, which, in almost every case, was greatly distorted by the force of compression acting in that direction. It is probable that those of the cylindrical form would have yielded in like manner, had the riveting at the joints been equally perfect on the lower side of the tube. This was not, however, the case, and hence arise the causes of rupture at that part.

The next experiments, and probably the more important, were those of the rectangular kind; they indicate a considerably increased strength when compared with the cylindrical and elliptical forms; and, considering the many advantages which they possess over every other yet experimented upon, I am inclined to think them not only the strongest but the best adapted (either as regards lightness or security) for the proposed bridge.

Rectangular Tubes.

No. of Experiments.	Distance between supports		Depth in inches.	Width in inches.	Thickness of Plate in inches.		Ultimate Deflection in inches.	Breaking Weight in lbs.	Remarks.
	ft.	in.			top.	bottom.			Broke by
14	17	6	9·6	9·6	·075	·075	1·10	3,738	Compression.
14	17	6	9·6	9·6	·272	·075	1·13	8,273	(Revers'd) Extens
15	17	6	9·6	9·6	·075	·142	0·94	3,788	Compression.
15	17	6	9·6	9·6	·142	·075	1·88	7,148	Extension.
16	17	6	18·25	9·25	·059	·149	0·93	6,812	Compression.
16	17	6	18·25	9·25	·149	·059	1·73	12,188	Ditto
17	24	0	15·00	2·25	·160	·160	2·66	17,600	Ditto.
18	18	0	13·25	7·50	·142	·142	1·71	13,680	Ditto.
23	18	6	13·00	8·00	·066	·066	1·19	8,812	Compression. Circular bottom, fin at top.
29	19	0	15·40	7·75	·230	·180	1·59	22,469	Sides distorted. Corrugated top

On consulting the above table, it will be found that the results, as respects strength, are of a higher order than those obtained from the cylindrical and elliptical tubes; and particularly those constructed with stronger plates on the top side, which, in almost every experiment where the thin side was uppermost, gave signs of weakness in that part. Some curious and interesting phenomena presented themselves in these experiments,—many of them are anomalous to our preconceived notions of the strength of materials,—and totally different to any thing yet exhibited in any previous research. It has invariably been observed, that in almost every experiment the tubes gave evidence of weakness in their powers of resistance on the top side, to the forces tending to crush them. This was strongly exemplified in experiments 14, 15, 16, &c., marked on the drawings and the table. With tubes of a rectangular shape, having the top side about double the thickness of the bottom, and the sides only half the thickness of the bottom, or one-fourth the thickness of the top, nearly double the strength was obtained. In experiment 14, (marked in the margin of the above table,) a tube of the rectangular form, 9¼ inches square, with top and bottom plates of equal thickness, the breaking weight was 3,738 lbs.

Riveting a stronger plate on the top side, the strength was increased to 8,273 lbs.

The difference being 4,535 lbs.,—considerably

more than double the strength sustained by the tube when the top and bottom sides were equal.

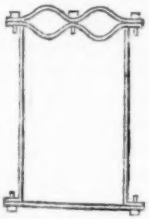
The experiments given in No. 15 are of the same character, where the top plate is as near as possible double the thickness of the bottom. In these experiments, the tube was first crippled by doubling up the thin plate on the top side, which was done with a weight of 3,788 lbs.

It was then reversed with the thick side upwards, and by this change the breaking weight was increased to 7,148

Making a difference of 3,360 lbs.

or an increase of nearly double the strength, by the simple operation of reversing the tube, and turning it upside down.

The same degree of importance is attached to a similar form, when the depth in the middle is double the width of the tube. From the experiments in No. 16, we deduce the same results in a tube where the depth is 18¼, and the breadth 9¼ inches. Loading this tube with 6,812 lbs. (the thin plate being uppermost,) it follows precisely the same law as before, and becomes wrinkled, with a hummoc rising on the top side so as to render it no longer safe to sustain the load. Take, however, the same tube, and reverse it with the thick plate upwards, and you not only straighten the part previously injured, but you increase the resisting powers from 6,812 lbs. to 12,188 lbs. Let us now examine the tube in the 29th experiment, where the top is composed of corrugated iron, as per sketch, forming two tubular cavities extending longitudinally along its upper side. This, it will be observed, presents the best form for resisting the "puckering," or crushing force, which, on almost every occasion, was present in the previous experiments. Having loaded the tube with increasing weights, it ultimately gave way by tearing the sides from the top and bottom plates, at nearly one and the same instant after the last weight, 22,469 lbs., was laid on.



The greatly increased strength indicated by this form of tube, is highly satisfactory, and provided these facts be duly appreciated in the construction of the bridge, they will, I have no doubt, lead to the balance of the two resisting forces of tension and compression.

The results here obtained are so essential to this enquiry, and to our knowledge of the strength of materials in general, that I have deemed it essential, in this abridged statement, to direct attention to facts of immense value in the proper and judicious application, as well as distribution, of the material in the proposed structure. Strength and lightness are desiderata of great importance,—and the circumstances above stated are well worthy the attention of the mathematician and engineer.

For the present we shall have to consider not only the due and perfect proportion of the top and bottom sides of the tube, but also the stiffening of the sides with those parts, in order to effect the required rigidity for retaining the whole in shape. These are considerations which require attention; and till further experiments are made,

and probably some of them upon a larger scale, it would be hazardous to pronounce anything definite as to the proportion of the parts, and the equalization of the forces tending to the derangement of the structure.

So far as our knowledge extends,—and judging from the experiments already completed,—I would venture to state that a tubular bridge can be constructed, of such powers and dimensions as will meet, with perfect security, the requirements of railway traffic across the Straits. The utmost care must, however, be observed in the construction, and probably a much greater quantity of material may be required than was originally contemplated, before the structure can be considered safe.

In this opinion Mr. Hodgkinson and myself seem to agree; and although suspension chains may be useful in the construction in the first instance, they would nevertheless be highly improper to depend upon as the principal support of the bridge. Under every circumstance, I am of opinion that the tubes should be made sufficiently strong to sustain not only their own weight, but in addition to that load, 2,000 tons equally distributed over the surface of the platform, a load ten times greater than they will ever be called upon to support. In fact, it should be a huge sheet iron hollow girder, of sufficient strength and stiffness to sustain those weights; and, provided the parts are well proportioned, and the plates properly riveted, you may strip off the chains, and leave it as a useful monument of the enterprise and energy of the age in which it was constructed.

In the pursuit of the experiments on the rectangular as well as other description of tubes, I have been most ably assisted by my excellent friend Mr. Hodgkinson; his scientific and mathematical attainments render him well qualified for such researches; and I feel myself indebted to him for the kind advice and valuable assistance which he has rendered in these and other investigations. I am also deeply indebted to yourself and the Directors for the confidence you have placed in my efforts, and for the encouragement I have uniformly received during the progressive development of this enquiry.

But, in fact, the subject is of such importance, and the responsibilities attached to it are so great, as to demand every effort to demonstrate, calculate and advise what in this case is best to be done. Both of us have therefore labored incessantly at the task, and I am indebted to my friend for the reduction of the experiments, which I would not attempt to weaken by a single observation.

WM. FAIRBAIRN.

Subject to be Continued.

Proceedings of the Institution of Civil Engineers. Extracted from the London Athenæum.

On the Incrustation of Steam Boilers. By W. West.—*February* 17, 1846.—The conclusion to which Mr. West arrived, as the best means of precaution against incrustation, was the selection of waters which, by analysis, were found to contain only soluble salts; or, in situations where bad water could alone be obtained, that the boiler should be frequently blown through, in order to get rid of the dense saturated part of the water, before the crust had time to be deposited.

In the discussion which ensued, Mr. Gooch stated that his attention had been called to a process invented by Dr. Ritterbandt for preventing incrustation in boilers. That process consisted simply in the addition of a small quantity of muriate of ammonia to the water in the boiler, and it had been found that this process not only effected the object proposed, but that it disintegrated and removed the incrustation already formed. Dr. Ritterbandt stated the results of his investigations; from which it appeared that carbonate of lime was the only substance which formed a solid incrustation; the other substances being merely mixed with, and cemented by the carbonate: that the muriate of ammonia acted as a solvent on the carbonate, converting it into the soluble muriate, without acting upon the boiler.

March 3.—The discussion upon the Incrustation of Boilers was renewed, and it was attempted to be shown, that, viewed chemically, the muriate of ammonia might act prejudicially upon the copper and iron of boilers; that the two metals in combination with a saline solution would induce a powerful galvanic effect, and, if aided by the unequal action of heat, producing a thermo-galvanic circuit, considerable deterioration of the boiler would ensue. It was instanced that, on applying a small quantity of the muriate of ammonia in a locomotive boiler, the incrustation was immediately removed from the tubes; hence it was argued, that a chemical action upon the metal must have taken place. On the other hand, after contesting the correctness of the chemical view assumed, it was asserted that, from the small quantity used, no perceptible chemical action could ensue; and that, in practice, after several severe trials of long duration, when the water was subjected to the most delicate tests, no traces of metal could be discovered. It appeared that the action of the muriate of ammonia upon the carbonate of lime forming the incrustation was merely to disintegrate it and render it soft and easy to be removed—for that after a given weight of incrustation had been boiled in a solution of muriate of ammonia for several hours, although it was rendered soft and pulverulent, the same weight still remained, thus proving that no sensible chemical combination had taken place. Numerous instances were given of the success of Dr. Ritterbandt's invention.

Description of the Dinting Vale Viaduct on the line of the Sheffield and Manchester Railway. *By* A. S. Jee.—*Feb.* 24.—This viaduct consists of sixteen arches, five of which are of timber, and eleven of brick; the whole of the large piers, wings, outside spandrils and parapets, are built of stone. The five large arches, which are each of 125 feet span and 25 feet versed sine, are built of Memel timber; the main ribs of these arches are composed of planking three inches thick, bent and laid longitudinally and fastened together with oak trenails, and firmly stayed by means of wrought iron tie-rods. The smaller semicircular arches, situated at each end of the viaduct, are built of brick with stone quoins. They are of 50 feet in the span and 3 feet in thickness, and are built in a curve of 40 chains radius, the pins being wedge-shaped to suit the curve, leaving the faces parallel with each other. The entire cost of the viaduct (which was given in its various details in the paper) was stated to be 35,250*l.* 6*s.* 5*d.*, its total length 484 yards, and its greatest height about 125 feet above the water course. It was commenced early in 1843, and was opened in August 1844. The average cost of construction was calculated to be about 2*l.* 14*s.* per superficial yard, and 6*s.* 9*d.* per cubic yard, the viaduct being 8 yards wide.

System of Preparing the Transverse Sleepers and fastening the Rails upon them; invented by Sir John McNeill, *and employed on the Dublin and Drogheda Railway.—Feb.* 24.—The sleepers are half baulks, 12 inches by 6 inches at the junction of the rails, and intermediately half trees of larch with the bark on, not less than 8 inches by 4 inches, are placed with the round side upwards, at an average distance of 2 feet 6 inches apart. These sleepers are prepared for bearing the rails by fixing twelve at a time on a sliding table similar to that of a plaining machine; they are moved forward by steam power beneath two circular cutters, set at the given distance of the gauge apart, revolving very rapidly, and which pass through the whole series of sleepers cutting at a given inclination the seats for the rails. A slight stoppage of the table takes place as each sleeper is cut, in order to afford time for four drills to descend simultaneously and to pierce the holes for the pins or trenails for holding down the rails. An engine of six-horse power suffices for working two of these machines, by which one thousand sleepers can be finished complete in twenty-four hours, at an expense of about one penny each, instead of twopence halfpenny each, which they formerly cost by manual labor. The sleepers thus prepared are used transversely beneath rails of the bridge, of which the sides are slightly pinched inwards in finishing, so as to form a dovetail, with a joint plate with a raised rib, which is laid at each junction, and which, by using a screw-pin and plate at one end and a collar-headed pin at the other, holds the rail very fast, preventing lateral and vertical motion, but permitting longitudinal action in expansion and contraction. These rails weigh 83lb. per yard. The total cost per mile of the double line, including rails, sleepers, pins, spikes, joint chairs, &c., laid complete, is stated at 3,470*l.* 2*s.* 8*d.*, when the rails cost 7*l.* 5*s.* per ton.

On the subject of the permanent way of the Dublin and Drogheda Railway, it was argued that although, if taken at weight for weight, there could be no doubt of the superior strength of the double T shaped rail over the bridge-shaped rail, yet that in practice the traveling on the Dublin and Drogheda Railway was remarkably smooth and equable; which, it was contended, resulted from the firmness of the attachment of the bridge rail direct upon the sleepers, and from the general perfection of the laying of the line. On the other hand, it was shown that a lighter double T shaped rail, with good cast-iron chairs and wooden trenails for fastenings, and fixed upon triangular sleepers, as on the South-Eastern, would, if the same machinery had been used in the preparation, and the same attention given to the laying down, have produced a better line. It was admitted, that the great points in establishing a railway, were to have heavier rails and stronger chairs, laid with accuracy, and constantly attended to; but that even then, unless the carriages were well constructed and adapted for their load, no smoothness or uniformity could be insured.

An Account of the Drops used for the Shipment of Coals at Middlesborough-on-Tees, with a description of the Town and Port. By G. TURNBULL.—*March* 10.—The communication first gave an account of the town; and then described the docks, and the coal-drops used there. The rapid rise of the town into commercial importance was accounted for, chiefly by the fact of a branch having been constructed, from the Stockton and Darlington Railway, to Middlesborough, which, as a port for shipping, possessed advantages over Stockton. The approach to the dock was stated to be by a channel of more than a quarter of a mile in length, which was kept open by sluicing; the entrance lock, built of stone, was 132 feet long by 30 feet wide, and the area of the dock itself was about 9 acres. The branch railway diverges from the Stockton and Darlington line, and terminates in ten double lines, leading to the ten coal-drops. The manner of working the drops was thus described: the loaded wagon is run on to a cradle or stage, which is arrested in a position immediately over the hatchway of the vessel to be loaded; it is then let down perpendicularly by means of counterbalance weights, and when it has nearly reached the deck, the contents are discharged into the hold; the counterbalance weights then preponderate, and the wagon is raised. About thirty wagons can be discharged an hour by each drop. In a statement annexed it is mentioned that in the year ending July 1, 1845, 505,486 tons were shipped by means of the ten drops. The cost of the drops was 7,300*l.*; the total outlay for the whole works amounted to 122,000*l.*

FRANKLIN INSTITUTE.

Committee on Science and the Arts.

Report on Cut-off Valves, by Cook & Seckel, and by R. L. Stevens.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred an application from the Hon. Robert J. Walker, Secretary of the Treasury of the United States, for their opinion as to the comparative merits of the Cut-off Valves of Mr. R. L. Stevens, and those of Messrs. Cook & Seckel, Report:—

That they have examined the construction of the valves of the parties named, on board of the steamboats New Philadelphia, in the Delaware, and Transport, at New York, and on board the Balloon, in the Delaware, and the Rhode Island, running between New York and Stonington; and are enabled to give such descriptions of them as will, they hope, render their construction intelligible to every one interested in the question.

The cut-off apparatus of Mr. Stevens, examined on board the New Philadelphia and elsewhere, consists of an eccentric, with a frame rod, connecting it with a lever on a rock-shaft, by means of a wrist pin; upon which rock-shaft there are lifters, or "wipers," as they have been termed, which raise the valve rods, and thus lift, by means of arms, the induction valves. The lifters or wipers are longer, and project further out than the lifters of ordinary valves; when in motion they raise the induction valves quicker than the ordinary lifters, and also close them more rapidly. The lever of the rock-shaft is constructed with a slot, in which the wrist pin is secured by a screw nut and washer, by means of which the distance or height of the lift may be adjusted. The frame rod from the eccentric may be lifted off of the wrist pin upon which it rests, by a hook in the usual manner, so that its connexion with the induction valve may be removed at will, and the engine thus brought under the action of the hand gearing.

In the arrangement examined by the committee on board of the New Philadelphia, the parts are fixed and imperative, with the exception of the ability to detach, as mentioned above, unless the engine be stopped, when all the parts can be set, so as to adjust the cut-off to any point.

The committee have seen the improvements which have been made, and are now in use, on board the Transport; they are of the following character:—In the first place, a screw has been added whose motion is in the direction of the slot in the lever of the rock-shaft, by means of which the amount of lift may be altered, whilst the engine is in motion; in the second place, by an arrangement of set screws attached to the lifters, by which they may be adjusted in like manner; and, lastly, by other means of adjustment consequent to the foregoing, so that the whole may be altered successively, without the necessity of stopping the engine.

The last means of adjustment referred to in the foregoing paragraph, is the shifting of the eccentric so as to change the *time*, or *lead*, as the case may be; plans have been exhibited to the committee by which this result may be accomplished, and evidence has been laid before them, that such change has been effected, during motion; but the committee are not satisfied that it can be done with safety or certainty in all cases, and are under the impression that it will be attended with great difficulty, where there is rapid motion. These means of adjustment have the disadvantage consequent upon loose parts, in their liability to derangement, of which the following is an enumeration: movable fittings in the lifters; in the wrist pin, which must move in its slot, and a loose eccentric, the failure of any one of which must stop the engine.

The committee have no reason to doubt the practicability of the changes required, and do not hesitate to state their conviction that the apparatus may be brought under the entire control of the engineer, with the exception in regard to the eccentric, before mentioned.

On board of the Balloon and the Rhode Island, the committee had good opportunities of seeing the cut-off apparatus of Messrs. Cook & Seckel, which they will now proceed to describe.

It consists of slide latches, moving upon the lifting arms of the valve rods, which are kept forward by spiral springs; these latches (which are forked so as to embrace the stems of the valves) pass under two long lugs, as they may be termed, placed one on each side of the valve stem, so that the valve is lifted to the desired extent by the slide and arm, when the former is drawn back, permitting the valve to fall to its seat, the stem passing freely through the arm from the lifting rod. The outer or back end of the forked slide is furnished with a mortise, through which an upright passes; upon the extremity of the upright there is an inclined plane or wedge; this last described part is secured to the steam pipes or chest, by screw fixtures.

The action of this arrangement is as follows:—As the rod rises with the valve, the slide first mentioned touches the inclined plane of the upright, and is drawn back by it, so as to liberate the lugs on the valve, when the valve falls to its seat. The screw fixtures of the upright are capable of adjustment or removal, so that the valve may be set to cut off, or work, whole stroke, at any time. As the valve falls not only by its own weight, but aided by the pressure of the steam, an arrangement is appended to modify the shock or jar, from the sudden fall of the valve, called, technically, a *Dashpot*, consisting of a cavity of a size adapted to receive a disk or plunger upon the end of the valve stem, with a sufficient space to allow water, with which it is filled, to escape gradually, so as to ease off the fall of the valve.

The Balloon is furnished with an arrangement as above described, attached to the upper and lower induction valves, requiring separate adjustments for the cut-off upon opposite ends of the cylinder. The committee is informed that a connecting rod, with a single adjustment, had been contrived, by which both valves could be controlled

at the same time, either as to the adjustment of the cut-off, or its removal, without interrupting the play of the engine.

It has been represented to the committee that the foregoing description of the cut-off on board the Balloon, is not the avowed arrangement of Messrs. Cook & Seckel, but they are satisfied that it is the same in principle and mode of operation, differing only in the form and arrangement of the parts—so that the description as given is substantially applicable in all respects. On board the Rhode Island the Dashpot apparatus is placed above, and there are other differences of construction; but, as above remarked, the result which is arrived at is the same.

The committee, after mature consideration, are of opinion, that these different modes of cutting off the steam in engines worked expansively, have, severally, advantages peculiar to each, and disadvantages inseparable also from them, which will be briefly stated in illustration of their views of the question submitted to their judgment.

Stevens' cut-off has the advantage of construction, in permitting an unlimited lead to be given to the exhaust, so that the engine can be prepared for the efficient action of the steam on its admission, and by which, accidents from condensation in the cylinder can be avoided. This arrangement also permits the steam to be cut off at any point from the commencement to the termination of the stroke.

Its disadvantages are confined to the complexity arising from the necessity of a separate eccentric, rod, rocking-shaft, &c., and to the additional weight and space which these parts call for in construction. The cut-off cannot be exactly the same on both ends of the cylinder, the arcs described being different when the eccentric is upon opposite sides of the shaft. They believe, also, notwithstanding the assurances of parties who have been consulted, that considerable difficulty will be found in altering the cut-off, whilst the engine is in motion, especially as a change in the position of the eccentric is essential.

The cut-off apparatus of Messrs. Cook & Seckel has a decided advantage in its simplicity and economy of construction: it admits, with facility, of change or removal, during the motion of the engine. It has the advantage of rapid action, the cut-off being nearly instantaneous.

In the form in which the committee inspected the apparatus, its operation was confined to some point less than half stroke; they are satisfied, however, that it is not limited to this extent, but may be made to cut off at nearly all points, by apparatus, not complex to an excessive degree, and not such as to change in a material manner its general features; lastly, if any part should fail, it may be detached, and the engine worked at whole stroke.

Its disadvantages are confined to the inability to give more than a limited lead to the exhaust, which is therefore not so fully under the control of the engineer as that of its rival, and to the fact, that there is a time at and near the change of motion of the lifter, presenting difficulty in the cut-off at and near half stroke.

The committee, under the influence of these views, have some embarrassment in giving a decided preference to either of these arrange-

ments; they have no doubt that both of them are capable of operating efficaciously, but a comparative estimate of the advantages and disadvantages of each, have led to the conclusion that neither has merits that could be determined, to the exclusion of the other, in a perfectly satisfactory manner, without a sea voyage, under similar circumstances in all respects, or which had not stood the test of time and service with competent and impartial engineers.

By order of the Committee,

WILLIAM HAMILTON, Actuary.

Philadelphia, April 9, 1846.

Report on Parker's Water Wheel.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, to whom was referred for examination a Water Wheel invented by Zebulon Parker, of Newark, Licking county, Ohio, REPORT:—

That the wheel of Mr. Parker, secured by patents of October 1829, (Journal of the Franklin Institute, 2nd Series, Vol. v, p. 33,) and June 1840, (Ibid. 3rd Series, Vol. ii, p. 135,) consists of an annular space included between two concentric cylinders, and closed above and below. This space is divided into compartments by means of curved partitions or paddles, against which the water acts to turn the wheel. The wheel is mounted upon an axis either vertical or horizontal, and the water is introduced into the interior, by means of a spiral inclined plane or helix, by which it is delivered at the inner circumference of the wheel very nearly in the direction of the tangent to its motion. The curve of the buckets is so laid down, that the water issues from the external circumference, with no more velocity than that necessary to clear it from the wheel.

The whole wheel and its helical sluice are introduced into an air-tight box, called by Mr. Parker 'a draft,' or 'draft-box,' which is kept perfectly tight by being immersed in the penstock, and into which water can find admission only by passing through the wheel; proper arrangements are made for carrying off the water as fast as it is delivered by the wheel.

For a more detailed description of the wheel, the committee refer to the descriptions in the patents above cited, and to the models and drawings with which Mr. Parker has furnished the Institute.

A very slight examination of these descriptions, models and drawings, will show that Mr. Parker's wheel is a true wheel of pressure, or 'turbine,' in which the helical sluice has been substituted for the curved guide placed by M. Fourneyron in the interior of his wheel; it might therefore be expected that, provided the curved paddles of the wheel be properly constructed, the practical coefficient would approach, at least, that given by the ordinary turbine; and the experiments tried by your committee have satisfied them that this is in fact the case.

Mr. Parker himself, in a letter addressed to the Actuary of the Institute, has explained the advantages which he expected to gain by the introduction of the draft-box, and these are evidently great enough to be secured, even at the sacrifice of some of the power of the machine. "By this arrangement (the introduction of the draft-box into the penstock) we are enabled to place the wheel at any convenient height within the compass of the head and fall, and still have the whole descent of water operate upon it. In some instances of sawmills of 17 and 18 feet head and fall, the axis of the wheel (which is horizontal) has been placed 8 feet above the surface of the lower level, and the power of the mill appeared in every instance to be the same that it would have been if the wheel had been placed at the bottom of the whole descent. This is often a great convenience, as the wheel may be placed in a situation in which it can be but little impeded by the rise of large streams, and frequently reduces the pitman to a proper length, which otherwise would have to be made so long that it would vibrate or tremble. Another important advantage of this arrangement is, that the wood work necessary for the wheel being submerged, cannot be injured by the changes of the air, and will consequently be very durable; and the wheel is effectually secured from frost in the coldest weather."

While, however, the committee acknowledge the advantages to be thus gained, (and another may be added to them, viz., facility of access at any time to the bottom of the wheel for examination or repair,) they believe that the maximum of useful effect, other things being the same, will always be found by placing the wheel as nearly as may be on the level of the water in the tail-race, so as to suffer as great a column of the water as possible to act directly by its pressure upon the wheel.

In reference to the experiments the committee regret, that in consequence of the distances from the city of the places at which Mr. Parker's wheels were established, and in consequence of the other occupations of the members of the sub-committee, and of Mr. Parker himself, there has been no opportunity to arrange and execute a complete and satisfactory set of observations upon a good wheel. The circumstances under which the experiments have been tried, have been in every case unfavorable to the wheel, and it is not believed that the results which they show, are in any case equal to the maximum useful effect to be obtained from the wheel when properly established and working under favorable circumstances; yet as they establish the decided excellence of the wheel, and as it is not probable that they can be extended or repeated, for some time at least, the committee report the results.

The useful effect of the wheel was tested by the application of Prony's friction dynamometer, an instrument which furnishes the most speedy, convenient and accurate measurement of the power conveyed to the axle upon which it is established, and of which a description will be found in the Journal of the Institute, (3rd Series, Vol. v, p. 225.) The number of revolutions of the wheel was counted by means of a dial connected with a spur-wheel, operated on by

an endless screw placed upon the axis of the wheel, but so arranged that it could at any moment be thrown out of adjustment, or re-adjusted, at the pleasure of the operator. The disk rotates under an index, which can either be allowed to revolve with the disk, or by the pressure of the finger upon its axis be stopped, and suffer the disk to revolve under it without partaking of its motion. This arrangement, which was devised and executed by Mr. Parker, furnishes a very easy and very accurate method of counting the revolutions of the wheel.

For the purpose of measuring the quantity of water which passed the wheel in a given time, the committee made use of a plan also devised and executed by Mr. Parker, which appears to be the simplest and best yet proposed for estimating the water.

A waste-board was established in the tail-race, sufficiently far from the mill to be out of reach of any commotion which might be excited in the water by the wheel, yet near enough to be perfectly under the inspection of the committee; (the wheel under consideration delivers its water so quietly, that the waste-board may be established within a few feet of it.) In this waste-board was cut a rectangular notch, with square sharp edges, having a length sufficient to pass a given number of cubic feet per minute, (greater than the maximum expenditure of the wheel,) with a given depth of water over the bottom of the notch. This notch might be closed water-tight by a sliding board which was so graduated as to read off the number of feet which could pass the opening, with a given length of notch, under the fixed height of the water. This fixed height was maintained by means of two boards projecting at right angles from the waste-board, sufficiently far towards the wheels to reach that part of the tail-race, the level of the water in which was not affected by the fall over the notch of the waste-board. As these boards included between them and the sides of the tail-race, a space in which the water was tranquil, the true level of the water in the tail-race was thus brought down to the waste-board, and by adjusting the slider until the water rose exactly to the level of the upper edges of the projecting pieces, (which were made perfectly horizontal,) the proper depth over the bottom of the notch was accurately preserved. The accuracy of the adjustments and graduating was first fully ascertained. The difference of level between the water in the head and tail-race was measured by means of a float with a graduated stem, and was carefully watched during the experiment.

The following tables exhibit the results of the experiments:—

TABLE FIRST.

***Experiments upon a Wheel** 36 inches in diameter; the aggregate openings for the issue of the water amounting to* 150 *sq. inches; axis vertical; established at Mr. Bancroft's Woollen Factory on Ridley Creek, Delaware county,* 11*th December,* 1845.

	POWER EXPENDED.				EFFECT PRODUCED.				
No. of Experiment.	Fall of water in feet & 10ths $=h$.	Cubic ft. per minute.	Lbs. of water per minute. $=w$.	Actual power of water. $h \times w = p$.	Weight on lever. $=w$	Revolutions per minute. $=v$.	Effective force of wheel. $w' \times v \times 50 = f$.	Ratio or Practical coefficient. $=\frac{f}{p}$	
1	7·18	1172	73250	525937	0.	225·25	0.	0.	
2	7·248	1020	63750	462060	31·5	154·33	243069·75	·526	
3	7·265	980	61250	444881·25	36	144·25	259650	·584	
4	7·29	940	58750	428287·50	45	120	270000	·630	
5	7·30	920	57500	419750	50	106	275000	·655	
6	7·31	900	56250	411267·50	54	99	267300	·650	·6519
7	7·31	890	55625	406618·75	54	98	264600	·6507	
8	7·32	880	55000	402600	57	89·50	254975	·633	
9	7·325	875	54687·50	400586	57	88	250800	·626	
10	7·33	870	54375	398568·75	61	80	244000	·612	
11	7·34	854·5	53406·25	392001·875	65	71	230750	·589	
12	7·345	850	53125	390203·125	69	65·50	225975	·579	
13	7·35	834	52125	383118·75	74·5	51	189975	·496	
14	7·355	825	51562·50	379242·19	76	43·25	164350	·433	
15	7·358	825	51562·50	379396·875	79	43·50	171825	·453	
16	7·36	810	50625	372600	81	35·50	123727·50	·332	
17	7·36	793	49562·50	364780	86	0.	0.	0.	

The mean of the experiments at working velocities with this wheel is ·6519: the quantity of water discharged per minute varying from 890 to 920 (mean 903) cubic feet: the difference of levels of the water in the head and tail-race 7·3 feet: the load upon the end of the brake lever from 50 to 54 (average 53) pounds: the circumference described by the end of the brake lever 50 feet: the number of revolutions per minute from 98 to 106, (mean 101.)

This wheel was not erected under Mr. Parker's personal superintendence, and an error had been committed by giving too steep a slope to the helical sluice, which materially diminished the good effect of the wheel; when this has been remedied, it will be interesting to have the experiments upon this wheel repeated.

TABLE SECOND.

Wheel established for driving the Cotton Factory of the New Brunswick Manufacturing Company. Wheel 40 *inches in diameter; aggregate openings* 200 *sq. inches; axis vertical; May* 9*th*, 1846.

POWER EXPENDED.					EFFECT PRODUCED.				
No. of Experit.	Fall of water. $=h$	Cubic feet per minute.	Lbs. of water per minute; 62½ lbs. per cub. foot. $=w$	Actual power of water. $h \times w = p$.	Weight on brake lever. $=w'$	Revolutions of wheel per minute. $=v$.	Effective force of wheel. $w' \times v \times 50 = f$.	Ratio or Practical co-efficient. $= \frac{f}{p}$	
1	10·04	1056·5	66031	662951	36·5	138	251850	·380	
2	10·025	1190	74375	745609	42	144	302400	·406	
3	10·07	1324	82750	833292	124	73	452600	·543	
4	9·935	1347·5	84219	836716	115	85	488750	·584	
5	10·00	1356·5	84781	847810	107	90	481500	·568	
6	10·055	1386	86625	871014	102	107	545700	·626	
7	9·97	1392	87000	867390	103	107	551050	·635	
8	9·995	1407	87937	878935	96	116	556800	·634	
9	9·74	1362	85125	829117	95	107	508250	·613	
10	10·03	1382	86375	866341	95	111	527250	·609	
11	9·90	1407	87937	870581	90	120	540000	·620	
12	9·955	1427	89187	887862	85	126	535500	·603	
13	9·998	1338	83625	836083	105	98	514500	·615	
14	9·87	1330	83125	820444	110	90	495000	·603	0·615
15	9·815	1282	80125	786427	115	85	488750	·621	
16	10·005	1345·5	84094	841360	110	90	495000	·588	
17	9·83	1357	848·2	833707	105	96	504000	.605	
18	9·995	1378	86125	860819	100	106	530000	·616	
19	9·92	1392·25	87016	863199	95	116	551000	·638	
20	9·96	1480·75	92·547	921768	90	124	558000	·605	
21	9·755	1834	114625	1118167	0	270	0	0	

These experiments were tried under very disadvantageous circumstances. The brake was established upon a shaft only 4½ inches in diameter, and the friction blocks were 3 feet long, and made of oak, with the grain running parallel to the shaft; the action was, consequently, very irregular. Moreover, the brake was not applied to the shaft upon which the wheel was placed, but to one connected with it by means of two spur wheels of large diameter; and passing nearly to the fourth story of the mill, supported by four bearings which had not been oiled for some time.

Mean of 15 experiments—with velocities varying from 85 to 126 revolutions per minute; loads upon the lever (the circumference described by whose end was 50 feet) varying from 85 to 115 lbs.; the quantity of water discharged per minute from 1282 to 1481 cub. feet; difference of the level of the water in the head and tail-race from 9·74 to 10·005 feet,—0·615.

TABLE THIRD.

The cotton factory at New Brunswick is driven by two wheels of different dimensions. The last set of experiments were tried with the larger wheel, the following were tried with the smaller.

Experiments with Wheel 36½ inches diameter; aggregate openings 150 sq. inches; axis vertical. May 22d, 1846.

	POWER EXPENDED.			EFFECT PRODUCED.				
No. of Exper't.	Fall of water. $=h$.	Cubic ft. of water per minute $=q$.	Actual power of water. $=p$. $=h \times q \times 62{\cdot}5$	Weight on lever. $=w'$	Revolutions per minute. $=v$.	Effective force of wheel. $=w' \times v \times 30$ $=f$	Ratio or practical coefficient. $=\frac{f}{p}$	
1	9·95	1348·25	838430·47	18	252	226800	·27000	
2	9·977	1306·75	814835	25	235	293750	·36000	
3	9·94	1278	793937·50	30	222	333000	·41565	
4	9·96	1257	783281·50	35	217	379750	·48482	
5	10·042	1234	774500	40	207	414000	·53454	
6	9·99	1206	753000	45	194	436500	·57968	
7	10·01	1174	734468·80	50	180	450000	·61269	
8	10·08	1149	723875	55	170	467500	·64613	
9	10·10	1110	700687·50	60	166	498000	·71073	
10	10·06	1127·50	708937·75	60	156	463600	·66000	·676
11	9·92	1054	653500	65	142	461500	·70620	
12	9·89	1072	662625	66	132	435600	·65739	
13	9·91	1049	649718·75	72	124	434000	·67600	

The mean coefficient determined by six experiments upon this wheel—with velocities varying from 124 to 170 revolutions per minute; load on the brake lever, (of the same length as in the last experiments,) from 55 to 72 lbs.; the quantity of water discharged per minute from 1049 to 1149 cubic feet; the difference of levels of the water in the head and tail-race from 9·89 to 10·1 feet,—0·676.

It was found impossible to carry the experiments beyond 72 lbs. upon the brake lever, which gave 124 revolutions per minute, although this was a speed materially greater than that for which the wheel was calculated. If the lever was loaded above this, rapid vibrations ensued, and the wheel suddenly stopped. Upon a subsequent examination this was found by Mr. Parker to be owing to the upper bearing of the wheel, within the penstock, (the arrangement being merely a temporary one,) having been made of wood, which, swelling by immersion in water, had subjected the wheel to a resistance, which could not be estimated. As this must have been in action during the whole of the latter part of the experiments, that is, during the experiments at working velocities, it is evident that the useful effect of this wheel must be greater than is indicated by the coefficient obtained in the experiments.

In conclusion, the committee regret exceedingly the incompleteness of their experiments, which has been caused by the impossibility of

devoting the necessary time and attention to their preparation; but, as circumstances render a report without farther delay desirable, they submit them as they are, and recommend the wheel of Mr. Parker to the attention of mill owners, as possessing the following advantages:

1. In regard to its useful effect it ranks with the overshot water wheel and turbine.
2. It possesses the peculiar advantages of the turbine, in reference to the action upon it of back-water or ice, and, like it, can be established either upon high or low falls.
3. It is simple in its construction, and of durable materials, and is for these reasons not expensive, and not liable to get out of order.
4. From its peculiar adjustment, easy access may be had to it at any time for the purpose of inspection or repair.
5. Running at high velocities, no intermediate gearing will be necessary, where such velocities are desirable.

By order of the Committee,

WILLIAM HAMILTON, Actuary.

Philadelphia, June 11, 1846.

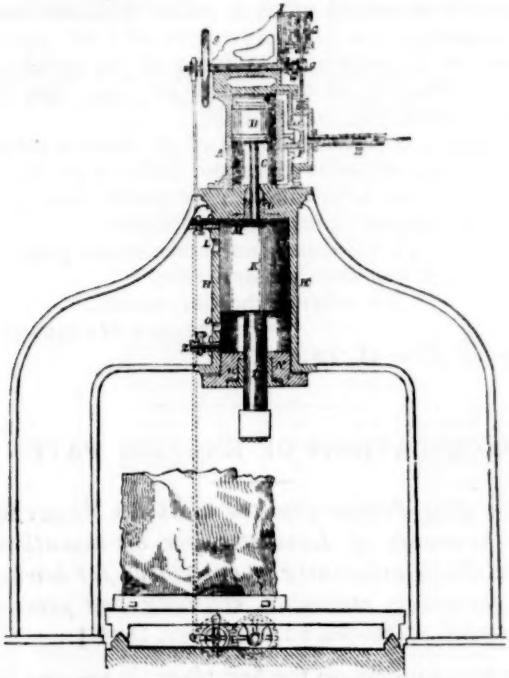
SPECIFICATIONS OF ENGLISH PATENTS.

Specification of a Patent granted to JAMES NASMYTH, *of Patricroft, in the county of Lancaster, for his invention of certain improvements in machinery or apparatus for hewing, dressing, splitting, breaking, stamping, crushing and pressing stone, or other materials.*—[Sealed 2d December, 1844.]

This invention consists, in the first place, in causing high pressure steam to exert its elastic force, in a direct manner, for alternately lifting up, and accelerating the fall of a piston, sliding in a vertical cylinder; to which piston certain chisels, cutters, stampers or hammers are attached, for the purpose of hewing, dressing, splitting, breaking, stamping, crushing and pressing stone, or other materials. And, secondly,—this invention consists in the peculiar manner by which the speed or number, as well as intensity of the blows, are modified, as may be desirable in the various stages of the before-named processes.

The drawing represents the improved apparatus in sectional elevation. It consists of a cylinder A, in which is fitted a piston B, and piston-rod C, working through a steam-tight stuffing-box D. The steam is conveyed to this cylinder from a suitable boiler, through a pipe E, so that by means of a slide-valve F, (in all respects similar to that generally employed in high pressure steam engines,) the steam is permitted to exert its elastic force upon the upper and under sides of the piston B, alternately, by the sliding up and down of the valve F, which receives its motion from a small piston sliding in a cylinder G, the piston-rod of which is at the same time the valve rod for the

valve F; the requisite amount of motion of this valve F, being regulated by a small crank and fly-wheel *g*, *g*, which, at the same time, gives the duly regulated motion to the valve of the small cylinder G, by means of an eccentric at W.



The piston-rod C, is attached to a cylindrical block of iron K, sliding nearly air-tight within a cylinder H, placed immediately under the cylinder A. Steam being admitted by a pipe at I, to the small cylinder G, it immediately gives a rising and falling motion to the valve F, the rapidity of which motion is regulated by the rate of admission and pressure of the steam let into the small cylinder G. While the valve F is being thus moved, steam is permitted to enter by the pipe E, and so obtain access alternately to the upper and under side of the piston B, which, together with its block K, is lifted up and forced down with a degree of force and rapidity due to the pressure of the steam on the piston B, together with the weight of the mass K. But as there would be nothing to limit the motion of the piston B, in its upward and downward action, except its coming in contact with the top and bottom of the cylinder A, which, in its action, would soon knock out and destroy that part of the apparatus, it becomes requisite to give a certain and definite motion to the piston B, and its block K. To attain this object the following means are adopted: In the cylinder H, above and below the upper and under sides of the block K, are spaces nearly equal to the spaces above and below the upper and under sides of

the piston B; the object of which is, that when the upper edge of the block K, in its upward motion, passes the hole L, the air remaining in the space M, M, is shut up and confined, and as it cannot escape so fast as it is compressed by the violent upward motion of the block K, it very soon acquires a degree of elasticity sufficient, not only to prevent all risk of the upper end of the block K, from striking the bottom of the cylinder A, and also that of the piston B, striking the top of the cylinder—but, what is of more importance, the so confined and compressed air exerts a powerful elastic action, which gives vast energy to the downward action or blow, which is given out by the fall of the block K, aided by the pressure of the steam on the top of the piston B, together with that of the compressed air on the upper side of the block K.

The patentee having thus described the manner in which the upward action of the block K is limited, he proceeds to state how the downward action of the block K, is also limited. It will be seen that the cylinder H, has a bottom at N, furnished with a nearly air-tight hole *n*, through which the chisel or cutter-holder T, slides; and, as the under edge of the block K, in its downward action, confines and compresses the air in the space P, P, by passing the hole O, it shuts up the air in the space P, P, in the same manner as in the upward action; so that, according to the degree of intensity with which the block K, is required to transmit its momentum to any object placed under the chisel-holder T, all that has to be done is to regulate the degree of compression of the air in the under chamber P, P, which is accomplished in the most simple manner, by having means to regulate the size of the escape aperture at Z. By this simple means, a species of elastic or springing blow is obtained, which allows of a delicate touch or powerful blow being given to any object placed under the chisel-holder T; besides which, the elasticity of the air-cushion in the chamber P, P, very importantly assists in recommencing the upward motion of the block K, without any jerk or destructive action whatsoever. The same means are also provided for regulating the elastic air-cushion in the upper chamber M, M. On the return stroke of the block K, the holes L and O, permit the air to re-enter, with perfect freedom, at every stroke.

It will now be evident, that by means of this apparatus, all due power and control being obtained over the energy of motion of the block K, its action may be applied to give the requisite lifting and falling action to certain chisels, cutters, stampers or hammers, such as may be attached or fixed to the end of the holder T, so that on placing an object, as a block of stone, or other material, under the chisels, and at a due distance, the surface of the stone will receive such a portion of the full force of the blow, arising from the fall of the block, as it may be desired to receive. In the case of hewing or chopping the surface of stones by such means, all that has to be done is to fix the stones on to a sliding-table, which has a progressive motion given to it in directions at right angles to each other; so that, by the combined or separate action of such sliding motion, all or any portion of its surface may be brought in succession under the action

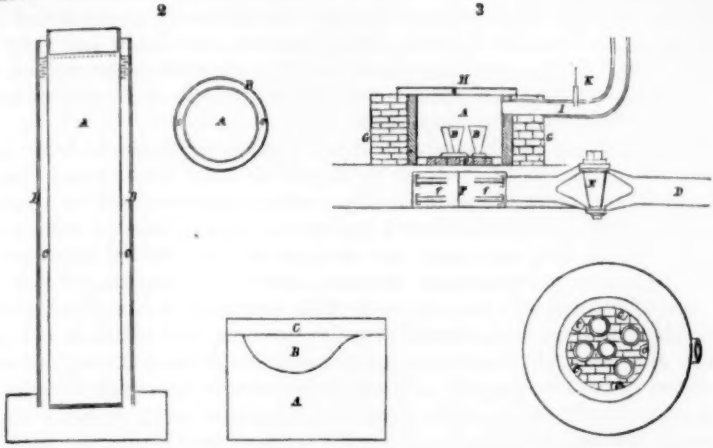
of the blows transmitted to it by the rapid rise and fall of the block K, and its attached chisels; and by the due regulation of the air-cushion under the block K, in the chamber P, P, powerful blows or delicate touches may be transmitted to its surface at pleasure, in any order or degree of variety, both as to force and rapidity; the air-cushion regulating the force, while the admission of the steam into the cylinders G and A, regulates the rapidity.

The patentee claims, Firstly,—the direct application of the elastic force of steam to raise and depress the tool or tools by which stones may be chipped or dressed, whatever may be the character or construction of steam-engine by which such elastic force is brought to act directly in raising and depressing the working chisel, pick, or other tool, that operates upon the surface of the stone. Secondly,—the employment of compressed air, or air-cushions, to temper or regulate the action of the steam-piston, and the intensity of the blow given by the tool in the act of striking the surface of the stone; also, the means described by which the elastic resistance of such volumes of compressed air are varied, in order to modify and determine the force of the striking-tool, according to the work under operation.—[*Inrolled June*, 1845.]

Specification of the Patent granted to CHARLES SANDERSON, *of Sheffield, in the County of York, for certain improvements in combining Steel and Iron into Bars, for Tyres for Wheels, and for other purposes.*—Sealed November 4, 1845.

To all to whom these presents shall come, &c., &c. In producing articles which require a large portion of their surface to be covered with cast steel of any description, two principal difficulties present themselves. Firstly, that of obtaining a perfect weld or union of the two metals; and, Secondly, as such union is obtained through the medium of heat, to obtain it without injury to the cast-steel. My mode of attaining this effectually and economically, I will now explain, which is as follows. I take iron which has been manufactured by the usual process into a bloom, of any form required; this is heated and passed between suitable grooved rollers, or placed under a hammer to form a cavity, of such depth and width as shall be sufficient to contain the quantity of steel required to be incorporated with the bloom of iron; this cavity being made, a small strip of iron is welded upon the face or open side, thus forming, from end to end, a tube or opening into which the fluid steel is to be poured, as is shown at figure 1, which represents the section of a bar according to my invention. A, represents the bloom of iron, produced by any of the ordinary processes of iron making. B, is the indenture or cavity made into such bloom whilst hot, by a hammer tool, passing it through suitable grooved rollers, or by any other convenient means. C, represents the small strip of iron, which is welded to the two outer edges, D, D, of the bloom of iron, thus leaving, throughout the whole length of the bloom,

the cavity, B, which is intended to be filled with steel in a fluid state.



Should it be required to cover two, three, or even four sides of the iron, this is effected by making cavities of such sizes and forms as may be required, so that when the bloom is further manufactured into that form for which it may be required, the steel may be found united to the iron exactly where it is required.

In covering pieces of iron, of a circular form, such as for the manufacture of rollers, piston rods, mandrils, &c., when the bloom of iron is obtained, to the form and size required, I make an outer tube of thin iron, of such dimensions, that the inside diameter shall be the size of the iron bloom, together with the thickness of steel required to be welded to its surface, the thin coating of iron being subsequently turned off in the lathe or ground away.

The section, A, figure 2, is the bar of the form required to be covered all over with steel; B, is an iron case, about the one-sixteenth of an inch thick, and C, shows the cavity which is intended to be filled with fluid steel; thus, if it is desired to coat the surface with steel one inch thick, it is evident that the outer rim must be made two inches larger in diameter than the piece of iron requiring to be coated. The iron being thus prepared for the reception of the steel, the bottom end being open, is stopped in any convenient manner, to prevent the fluid steel from escaping, when poured into the cavity.

The furnace usually employed for melting steel may be used, but for the purpose of obtaining the steel in a fluid state, as economically as possible, I prefer to use an arrangement, shown at figure 3, in which A, is the body of the furnace, containing two or more crucibles B, B, which rest on the bottom of the furnace C, which may be built of solid fire-brick, having holes pierced at convenient distances, marked C, figure 4, to allow the air, which is introduced from a blast machine through the pipe, D, and regulated by a cock or valve, E. The air chamber, F, may be formed of cast-iron plates, as well as the outer part of the furnace itself, G, G, having a small door, *f*, *f*, for the pur-

pose of cleaning the furnace when required. The fuel is introduced by removing the cover, H, and the redundant heat, smoke and gases, evolved, are allowed to escape through the chimney, I, regulated by a damper, K. In this furnace, I am enabled to obtain not only a greater but a more equal degree of heat by regulating the valves, E, and K, using at the same time, a fuel much inferior, and consequently less costly than that now employed.

The iron being made ready for the reception of the steel, and the lower end being closed, I draw the crucibles from the furnace above described, and pour the fluid steel into those cavities made to receive it, the crucible is then returned to its furnace to be recharged with steel. The blocks of iron and steel, not being united or welded together, I place them in a reverberatory furnace, such as is commonly used for the manufacturing of iron, and heat them gradually to a welding heat; each block is then withdrawn from the furnace, and submitted to the blows of a heavy hammer, for the purpose of effecting a perfect weld or union of the two metals. To effect this union, however, I prefer to pass each block as it comes from the furnace, at a welding heat, through rollers, or under a powerful press or squeezers, as usually employed in iron works, which, whilst it firmly unites the iron and steel, may be made to give the blocks that form which is most convenient for its succeeding manufacture, whether it be intended to hammer or roll the same into a tyre bar, or any other form.

Having thus described the nature of my said invention, and the manner of performing the same, I would have it understood that what I claim is,

Firstly, the mode of manufacturing blooms of iron, with cavities of any form or size desired, which are to be filled with steel in a fluid state, in the manufacture of articles requiring steel to be welded upon the surface.

Secondly, I claim the use of an outer coating of iron, when using melted cast-steel, in order to protect the steel from injury by fire, during the subsequent operation of welding the iron and steel together.

Thirdly, I claim the mode of pressing the iron and steel blooms, when at a welding heat, instead of hammering them, and during such pressure to give them such form as may be best adapted for their future manufacture.

Fourthly, I claim the use of the blast furnace, in contradistinction to the present air furnace, for melting the steel as herein specified.

Enrolled May 4, 1846.

MECHANICS, PHYSICS, AND CHEMISTRY.

Terms used in Mechanics.

I.—Efficiency—Laboring-force—Power—Duty.

Scarcely had mechanics been brought under the cognizance of mathematical investigation when a dispute arose respecting the mea-

sure of the force of a body in motion—a dispute which for half a century was conducted with more vehemence and acrimony than might be supposed incident to the nature of an abstract subject, and which "was rather dropt than ended, to the no small discredit of mathematics, which has always boasted of a degree of evidence inconsistent with debate that can be brought to no issue."* On one side it was contended that the true measure is found by multiplication of the weight of the body into its velocity ($W \times v$): while on the other it was contended with equal confidence that the proper measure is the product arising from the weight multiplied into the velocity squared ($W \times v^2$.) The former definition ($W \times v$) mainly supported by comparison of inertiæ, and the relations of bodies to a common centre of gravity in planetary systems, was most commonly received as the more simple and consistent. Still the question remained undecided, and adverting to the collision of elastic bodies, and that property of motion known as the principle of *vis viva* there seemed to be equal argument in favor of the definition ($W \times v^2$).

At length it was fortunately observed that the different properties indicated by these two functions were not in reality at variance with each other, and the terms *momentum* and *impetus* with their synonyma, reconciled all opinions, and removed the basis of the dispute. It was further observed that neither impetus nor momentum has much to do with practical mechanics, since neither of these functions measure directly the efficiency developed in ordinary machines. The criterion of their efficiency is the force multiplied by the space through which it acts ($F \times s$); and the effect thus developed, measured in the same way, has been appropriately termed *duty*—a term first introduced by Watt in ascertaining the comparative value of his engines when he had assumed as a dynamical unit a pound weight raised one foot high.† This definition is founded on the manifest assumption that the resistance remaining the same in every new point of space, the pressure must likewise be exerted afresh at every point through which the resistance is overcome. This does not directly apply to the case of a body projected by an impulsive force, for then the body ascends, supposing the impulse to be upwards, through a certain space, proportioned to the force accumulated in the body, in conformity with the laws of motion ; but if a body be raised slowly by a rope, we cannot for an instant relax our exertion, for if we do, the body immediately begins to descend, unless prevented by some special contrivance, in obedience to the law of gravity; and during the ascent we find that a new pressure is necessary to draw the body through every particle of space. Similarly, if a certain amount of exertion be requisite to saw through an inch of a uniform block, it will require an equal exertion to saw through the next inch of the

* Reid's Essay on Quantity.

† The dynamical unit termed a *horse-power* is 33,000 lbs., or 528 cubic feet of water, raised one foot high in a minute. The *Cheval Vapeur* of the French Engineers is 75 kilogrammes raised 1 metre per second; and as the metre is 3·28 feet and the kilogramme 2·2 lbs., the *Cheval Vapeur* will be equivalent to 31500 lbs., raised 1 foot per minute. It therefore follows that 100 English horse-power is equivalent to 105 French nearly.

same block; and after each exertion of force the object will remain where it is and as it is, unless a new exertion of force carry on the work. Hence we conclude that the laboring force exerted is proportional to the resistance and the space conjointly, and may be measured and expressed by the product of two numbers representing these quantities, that is by ($F \times s$).

Now, as every resistance may be expressed by weight, and the overcoming of resistance may be represented by raising a weight equivalent to the resistance so measured through a vertical space, it being always supposed that the weight will remain at the point to which it is thus raised, this affords a convenient mode of estimating and of representing the mechanical efficiency of a given mechanical agency. Thus, if it requires a force of 100 lbs. to draw a carriage along a road, the power expended in drawing the carriage through 50 feet may manifestly be measured by the laboring force which would raise a weight of 100 lbs. through a height of 50 feet. Hence the laboring force is independent of the nature of the work done—which is infinitely diversified by the mechanism employed; and it is also always equal to the sum of the effects produced. Much of it may be uselessly expended in the mechanism, and therefore lost for useful purposes, and hence the value of one species of machine as compared with another—that machine being the best which transmits the highest per centage of the power applied to it. Thus, if a man's weight be 100, and he be capable of raising a weight of 90 by a single pulley and rope, the duty is to the laboring force or power as 90 to 100, or 10 per cent. of the power has been expended in overcoming the friction of the pulley and the rigidity of the rope. By diminishing the amount of these resistances the duty may be correspondingly increased; or the same weight may be raised by a less expenditure of power. What is obviously true in this case is equally true of any mechanism however complicated. Thus, if F be the pressure exerted upon the first piece of mechanism in the direction of its motion, and S the space through which it moves in any given unit of time; and if f be the pressure exerted by the last piece of mechanism upon the work, and s the space through which it moves in the same unit of time; further, if p express the amount of power necessary to overcome the friction in the mechanism itself, then, whatever be the nature or extent of the train, we have

$$f \times s + p = F \times S.$$

By the same reasoning, the amount of laboring force corresponding to a given space is not altered by altering the velocity of working, provided the pressure F and f remain constant. But in many cases the pressure exerted changes with the change of velocity, and accordingly the power will vary with the varying rate of working; and there may be a rate of working for which the power is a *maximum*. Thus, a water-wheel would yield no mechanical efficiency at a velocity equal to that of the water which impels it; and taking the common formula to express the horse power of a locomotive engine, viz., $(L \times S) - 62{\cdot}5$ (in which L is the load in tons, and S the speed in miles per hour,) it is obvious, taking the limits of L and S at the load

which the engine is just capable of moving, and the speed which it would attain without any load, that the maximum of effect must lie somewhere between.

"In connexion with this subject it may be observed generally, that the conditions under which machines produce this maximum effect, may be considered either in respect of the mechanical effect which they are capable of deriving from a given exertion of the motive power, or in respect of the amount of mechanical effect which they are capable of exerting with reference to the expenditure of the impelling force. These conditions are moreover very rarely separable, so that to obtain a maximum effect in one sense, very commonly involves different conditions to those which would produce it in the other. To obtain the maximum effect from a given expenditure of motive force, the machine must be adapted to receive the greatest amount possible of the motive force, and not permit any portion of it to be expended without producing its full effect in impelling the machine. This most obviously depends upon the mechanical organs of the machine being perfectly proportioned to the forces which are to act upon them, according to the velocity, intensity, and direction of those actions, and must have reference to some particular velocity with which the motive force is required to impel the machine; but it is also equally obvious, that each kind of motive force having some particular velocity at which it can act with the greatest advantage, if we exact from the machine a higher velocity of motion than is consistent with the activity of the impelling power, we can only obtain it by a sacrifice of mechanical effect. Thus the useful effect due to animal exertion decreases rapidly as the speed increases. A horse, for instance, cannot move its limbs quicker than a certain velocity, even if it had no resistance to overcome; and it is only when working at the most advantageous speed that its mechanical effect can be valued at 33,000 lbs. raised 1 foot per minute.* On the other hand, a resistance may be opposed so great that the animal cannot move at all; and in this case, as well as in that of excessive velocity, no mechanical effect is realized. In the same manner the natural currents of wind and water are limited in the rapidity of their motions, and will act as motive forces most efficaciously when the recipients are adapted to their respective velocities; that is, when the parts of the machine to which the motion is applied act only at such velocities as to receive the whole force of the current. If the motion of the recipient be greater—should it approximate to that of the current—then a part only of the force will be realized; for the current, when it has passed from the machine, will retain the same velocity as the parts upon which it acted, and consequently a motive force corresponding to that velocity, which has produced no useful effect upon the machine. In like manner, the elastic force of steam is limited in the velocity of the motion with which it can act upon the piston (in the steam engine); and in the case of the locomotive engine, the velocity

* The average value of a horse is from 21000 to 22000 lbs. raised 1 foot per minute. What is known as a horse power in mechanics is really equivalent to one and a half times the power of the animal.

corresponding to the maximum effect may be passed. It is however to be remarked that this limit is brought greatly nearer by the practical necessity there is of contracting the apertures by which the steam is admitted into the cylinder; the motive force is thereby not permitted to act freely upon the piston, but only with a limited activity; and further, that certain of the resistances—the resistance, for instance, arising from the action of the atmosphere upon the train, and of the blast pipe against the piston—increase with the velocity, so that at a certain speed, easily determined by calculation (where the data are determined,) the augmented resistance becomes equal to the diminished motive force. This is the limit of velocity, for there being no preponderance of motive power, there cannot be any acceleration; and a dynamical equilibrium being established, the motion will continue uniform. Did these conditions not exist—had the steam no contracted orifices to pass through, and were there no augmentation of resistances with increased speed—then the velocity of a locomotive, and the power of steam engines generally, would be limited only by the rate of vaporization in the boiler."*

In any moving body there is accumulated by the action of the forces whence its motion has resulted, a certain amount of power which it reproduces upon any resistances opposed to its motion, and which is measured by the effect produced upon that obstacle. It is this accumulated power which has been called *impetus* by Dr. Wollaston, and *energy* by Dr. Young, and on which the dispute respecting the measure of dynamical force was so long maintained. Thus, in a ball fired from a cannon there is an accumulated power ready to be expended upon any obstacle it may encounter in its flight; and in the water which flows through the channel of a mill-lead there is accumulated the power which is transferred (in part) to the undershot wheel. Similarly, a carriage descending an incline, if allowed to descend freely, accumulates a power sufficient to carry it a considerable distance up the next incline. In those and analogous cases, the pressure for a time exceeds the resistance, and that surplus pressure is accumulated in the moving body, and it is easily shown that in every case, the power accumulated is precisely equal to the power expended upon the body beyond that necessary to overcome the resistance opposed to its motion; a principle, indeed, which might almost be assumed as in itself evident. It is likewise evident that the power accumulated in a moving body will be the same for the same velocity, under whatever circumstances that velocity has been acquired. Whether the velocity of a ball has been communicated by projection from a steam gun, or by explosion from a cannon, or by being allowed to fall freely from a sufficient height, it matters not to the result, provided the same velocity, v, be communicated to it in all three cases, and it be of the same weight, w, the power accumulated in it, estimated by the effect it is capable of producing, is evidently the same.

To estimate the power so accumulated in a body moving with a

* The Engineer and Machinist's Assistant, at present being published in monthly Parts. Blackie & Son, Glasgow.

given velocity, let us suppose that the body is projected with the velocity v in a direction opposite to gravity: by the laws of motion, it will ascend to the height h, from which it must have fallen to acquire the same velocity v; there must then at the instant of projection have been accumulated in it a force sufficient to raise it to the height h; but the number of units of power requisite to raise a weight w, to a height h, is represented by the product $w \times h$, for here h represents the space s, through which the force is exerted, and therefore $w \times h$ agrees with the definition $F \times s$. Now, cause and effect being equal, $w \times h$ will likewise express the number of dynamical units accumulated in the body at the instant of projection. But since h is the height from which the body must fall to acquire the velocity v, and since* $v = \sqrt{2gh}$ by the laws of falling bodies: therefore $h = \frac{1}{2}\frac{v^2}{g}$; hence replacing h by its equivalent in the expression $w \times h$ and taking U to represent the number of dynamical units accumulated, we have

$$U = \frac{1}{2}\frac{w}{g}v^2$$

It therefore appears that the power accumulated in a moving body, however its velocity may have been attained, whatever may have been the circumstances under which that velocity was acquired, is *proportioned* either to the *space* through which the moving force is exerted, or to the *square* of the velocity of the body in which such force is accumulated. "Thus a bullet moving with a double velocity will penetrate to four times the depth in a bed of clay of uniform consistence: a ball of equal size, but of one-fourth part of the weight, moving with a double velocity will penetrate to an equal depth. Thus also when the resistance opposed by any body to a force tending to break it, is to be overcome, the space through which it may be bent before it breaks being given, as well as the force exerted at every point of that space, the power of the body to break it, is proportional to its weight, multiplied into the square of its velocity." And from this it follows that to double the velocity we must apply four times the power. Thus, were it necessary to obtain a certain velocity by means of the descent of a heavy body from a height, to which we carried it by a flight of steps, we must ascend, if we wish to double the velocity a quadruple number of steps, and this will cost four-times as much labor. Glas. Prac. Mech. and Eng. Mag.

* The force of gravity is, in respect of the descent of bodies near the earth's surface, a constantly accelerating force, increasing the velocity of their descent by 32·2 feet in each successive second; in like manner if they be projected upwards, it becomes a constantly retarding force diminishing their velocity by that quantity each successive second of time. The symbol g is commonly used to denote the number 32·2 and is so used above.

On the Application of Voltaic Ignition to Lighting Mines. *By* **W. R. Grove, Esq.,** ***M. A., F. R. S., Professor of Experimental Philosophy in the London Institution.***

In the *Comptes Rendus* of the Paris Academy of Sciences for the 1st and 15th of September last, are communications by M. Boussingault and M. De la Rive, on the employment of the voltaic disruptive discharge for the illumination of mines. M. Boussingault is inclined to believe that some of the accidents in mines have occurred from draughts or currents of inflammable gas, and not from the carelessness of the workmen in the use of the safety-lamp, to which they are generally attributed; he considers that the voltaic arc, being independent of atmospheric air or other supporter of combustion, in the usual sense of the word, might be rendered practically available. M. De la Rive states that he has been occupied with the subject, and proposes a cylinder of close-textured charcoal, similar to that of Bunsen, with a metallic ring or plate above it; the carbon being rendered the positive terminal of a voltaic pile, the particles transferred from it to the disk fall down again by their own gravity, and a tolerably constant light is obtained; the vessel containing the electrodes is hermetically sealed, and the oxygen being soon exhausted by the ignited charcoal, the ignition proceeds in the residual nitrogen. M. De la Rive appears, however, to have met with but partial success, and says there are still many difficulties to contend with.

Four or five years ago, soon after publishing the nitric acid battery, I was naturally struck by the facility and constancy with which the voltaic arc could be obtained by that combination, as compared with any previous one, and made several attempts to reduce it to a practical form for the purposes of illumination, but my success was very limited. By attending to certain precautions, which I will not stop to describe, I could occasionally keep up a steady voltaic light in attenuated nitrogen for four or five hours, but it was never sure; from some unseen imperfection in the charcoal, or other cause, it would become suddenly extinct; the glass also in which it was ignited became gradually dimmed by a deposition of condensed carbon vapor; it was costly, from the number of series, and consequently of equivalents of zinc and acid consumed; too bulky for portable purposes, and from the intensity of the heat, unless the recipient was very large, the collar of leathers and joints, into which the wires were sealed or cemented, were destroyed; and when ground plates were employed, the grease was liquefied. M. de la Rive does not state his method of hermetically sealing the vessel he employs; this I found one of the most difficult parts of the process. Not being able satisfactorily to overcome these difficulties, I abandoned it for the time, and made some experiments on another method of voltaic illumination, which appeared to me more applicable to lighting mines; their publication was postponed, and I had nearly forgotten them, until reminded by the papers above mentioned.

I substituted the voltaic ignition of a platina wire for the disruptive

discharge. Any one who has seen the common lecture-table experiment of igniting a platina wire by the voltaic current nearly to the point of fusion, will have no doubt of the brilliancy of the light emitted; although inferior to that of the voltaic arc, yet it is too intense for the naked eye to support, and amply sufficient for the miner to work by. My plan was then to ignite a coil of platinum wire as near to the point of fusion as was practicable, in a closed vessel of atmospheric air, or other gas, and the following was one of the apparatus which I used for this purpose, and by the light of which I have experimented and read for hours:—A coil of platinum wire is attached to two copper wires, the lower parts of which, or those most distant from the platinum, are well varnished; these are fixed erect in a glass of distilled water, and another cylindrical glass closed at the upper end is inverted over them, so that its open mouth rests on the bottom of the former glass; the projecting ends of the copper wires are connected with a voltaic battery (two or three pairs of the nitric acid combination,) and the ignited wire now gives a steady light, which continues without any alteration or inconvenience as long as the battery continues constant, the length of time being of course dependent upon the quantity of the electrolyte in the battery cells. Instead of making the wires pass through water, they may be fixed to metallic caps well luted to the necks of a glass globe.

The spirals of the helix should be as nearly approximated as possible, as each aids by its heat that of its neighbor, or rather diminishes the cooling effect of the gaseous atmosphere; the wire should not be too fine, as it would not then become fully ignited; nor too large, as it would not offer sufficient resistance, and would consume too rapidly the battery constituents; for the same reason, *i. e.* increased resistance, it should be as long as the battery is capable of igniting to a full incandescence.

The helix form offers the advantages, that the cooling effect being lessened, a much longer wire can be ignited by the same battery; by this increased length of wire, the battery fuel is economised, while a greater light is afforded; by the increased heat, the resistance is still further increased, and the consumption still further diminished, so that, contrary to the usual result, the increment of consumption decreases with the exaltation of effect produced. The very necessity of inclosing the coil in a glass recipient also augments the heat, the light, and the resistance; if I remember rightly, Mr. Faraday first proposed inclosing wire in a tube for the purpose of being able to ignite a longer portion of it. Lastly, only two or three cells are required, (one indeed might be sometimes sufficient,) and the whole apparatus thus becomes portable and economical. The light is perfectly constant, subject to no fluctuation or interruption, and the heat is not so excessive as to destroy the apparatus.

As the effect of different gases on radiant heat is an important element in the practical application of the above, I had commenced some experiments on this subject, and the following I find in my note-book as the effect of four different gases. A voltameter was interposed in the circuit in order to furnish a better test of the amount of ignition

than the eye, as, according to the position of Davy, that a wire becomes a worse conductor in proportion to its increase of temperature, the amount of gas in the voltameter should be, as indeed in these experiments it turned out to be, in inverse proportion to the degree of ignition. As a further test, the increased volume of the gas by expansion was noted, though the apparatus was not constructed for showing this increase with delicate accuracy.

Platina wire ignited by a given constant voltaic battery in	Effects to the eye.	Voltameter gave at the rate of one cub. in. in	Expansion of volume.
		"	
Hydrogen . . .	Not visible even in the dark .	19	35 to 43
Carbonic acid .	Cherry-red by daylight . .	21·5	35 . . . 43
Oxygen	Incandescent by daylight . . .	23·5	35 . . . 45
Nitrogen	Same	24	35 . . . 45
Atmospheric air	Same	24	35 . . . 45

I had intended to have carried these experiments further with other gases,* and also with condensed and rarefied air, but was interrupted; and as it may be some time before I may be able to renew them, I think I cannot do better than submit these experiments, with your permission, to the readers of the Philosophical Magazine, while the attention of scientific men is directed to this subject; actual practice can alone test their efficacy. Lond., Edin. & Dublin Philos. Mag.

Telegraphic Communication between France and England.

Amidst the many wonderful inventions of modern days, wherein the faculties of man have overcome difficulties apparently insurmountable, and made the very elements themselves subservient to his power and use, there are none more wonderful than that now about to be carried out by the establishment of submarine telegraphs, by which an instantaneous communication will be effected between the coasts of England and France. The British Government, by the Lords Commissioners of the Admiralty, and the French Government, by the Minister of the Interior, have granted permission to two gentlemen, the projectors of the submarine telegraph, to lay it down from coast to coast. The site selected is from Cape Grisnez, or from Cape Blancnez,

* I have some doubt whether the different gases do not exercise a specific action on the ignited wire, somewhat in the nature of catalysis; if a wire be brought by the voltaic current to a white heat in atmospheric air, and a vessel of hydrogen inverted over it, the light is as suddenly extinguished as the flame of a candle would be.

on the French side, to the South Foreland, on the English coast. The soundings between these headlands are gradual, varying from seven fathoms near the shore on either side to a maximum of 37 fathoms in mid-channel. The Lords of the Admiralty have also granted permission to the same gentlemen to lay down a submarine telegraph between Dublin and Holyhead, which is to be carried on from the latter place to Liverpool and London. The submarine telegraph across the English Channel will, however, be the one first laid down: the materials for this are already undergoing the process of insulation, and are in that state of forwardness which will enable the projectors to have them completed, and placed in position, so that a telegraphic communication can be transmitted across the Channel about the first week in June. When this is completed an electric telegraph will be established from the coast to Paris, and thence to Marseilles. This telegraph, throughout France, will be immediately under the direction of the French Government, as, according to the law of 1837, all telegraphic communications through that country are under the absolute control and superintendence of the Minister of the Interior. Upon the completion of the submarine telegraph across the English Channel, it is stated that a similar one, on the most gigantic scale, will be attempted to be formed under the immediate sanction and patronage of the French Administration; this is no less than that of connecting the shores of Africa with those of Europe by the same instrumentality, thus opening a direct and lightning-like communication between Marseilles and Algeria. Railway Magazine.

Mr. Rand's inventions for the Manufacture of Flexible Metal Tubes for preserving Paint and other matters.

Mr. Carpmael stated that Mr. Rand, who is an artist, had, from the inconvenience and waste of color which takes place when it is put in the bladders ordinarily used, been led to endeavor to find a substitute, and the use of metallic vessels suggested itself. After experiments he succeeded in forming them of so thin a body of metal that they are capable of being collapsed so as to shut out all air. The tubes are made of block tin the 150th part of an inch in thickness, and have at their upper end a nozzle and screw cap, and are closed at the bottom by being folded over once or twice with a pair of pincers so as to exclude all air. As the color or other matter which they contain is pressed out, the tubes are collapsed and thus the upper part of the tube always remains full. Each tube has to go through the following process of manufacture:—A small piece of block tin is put into a die upon which a punch worked by a fly-press descends and forces the metal up, of the required thickness, between the surfaces of the die and the punch; thus by a single blow the body of the tube is formed. It is then removed to a second press, by which the screw on the neck of the tube is formed, and by a second blow, in the same press, the maker's name is stamped upon it. The cap is

formed in a similar manner by a third machine. The tube when struck is placed on a lathe and cut the required length. Thus an air-tight bottle is formed without seam in a few seconds.

Trans. Roy. Scot. Soc. of Arts, April 15.—Civ. Eng. and Arch. Journ.

On the Manufacture of Steel. By Dr. Carl Schafhaeutl.

(Translated from the Revue Scientifique et Ind. du Dr. Quesneville.)

Iron, in the composition of which a portion of the silica is replaced by manganese, will, while being smelted, rather part with the latter than the former. From this it follows, that at the moment when the iron is on the point of passing from a liquid to a solid state it will retain sufficient silica to form steel. For this reason, during the whole process of refining, the current of air is caused to act rather upon the surface of the metal than through the interior of the fluid mass, in order to avoid the combustion of too much carbon and silica; from which it follows that the casting becomes malleable without losing a sufficient quantity of silica to constitute iron, properly so called, and the product is raw or blistered steel. The casting which does not contain any manganese, loses, by the effect of combustion, a portion of silica proportionable to the quantity of carbon burnt, and furnishes iron only, as a definitive product.

It is simply to the mechanical action of the hammer that the distinctive features of steel, as compared with cast metal, are due. In order to effect this change, the blistered steel is broken into pieces and melted down; they are afterwards tempered—again broken into pieces, and welded together at a good welding heat. The steel will be the more malleable, and possess more tenacity and uniformity of texture, in proportion to the number of times these operations are repeated. The product is called "wrought or shear steel."

Steel of cementation and cast-steel.—When bar-iron is heated to a white heat, or even melted in close vessels containing coal or carbonaceous substances, it takes up a certain quantity of carbon, and is transformed into castings of various kinds.

If the iron contains, together with silica, phosphorus and arsenic in proportions suitable for softening the granular particles of iron during their combination with the carbon, by keeping it for a certain time at a red heat, with powdered charcoal, a casting is obtained, which, when submitted to the action of the hammer, or of rollers, furnishes a product known as "steel of cementation." During this operation, the stratum of oxide which covers the particles of iron inside loses its oxygen, and passes again into a metallic state; but the vacant spaces occasioned by this are filled up, as the ferruginous particles, which are in a semi-fluid state, re-assume the crystaline form. The carbonic oxide gas, in escaping, forms large blisters on the surface of the metal, under which the softened mass crystalizes. On being broken, the interior of these blisters, instead of appearing of a dark color, in-

dicating the presence of a stratum of protoxide, presents a brilliant and rainbow-tinted appearance, the yellowish and bluish tints distinguishing bronzed steel being observable. If this steel be wrought at a white heat, these blisters will weld in with the mass with the greatest facility. During cementation, the carbon combines with the component particles of the iron in various proportions, depending in a great degree upon the chemical composition of those particles. It is, therefore, a vulgar error to suppose that steel of cementation contains more carbon at the surface than in the interior, as stated in all technological treatises. Thus, in the best Dannemora steel, it very frequently happens, when the cementation is finished, that the centre of the metal contains a much greater quantity of carbon than the superficial portions. It may also happen that steel produced from the best Dannemora bar-iron will differ in an extraordinary manner as regards hardness, in various portions of the bar; and for this reason, in steel works in England, the bars of steel are always broken into several pieces, in order to class those pieces together which are the most similar in quality.

If ordinary iron be submitted to cementation, that is to say, iron in which the proportion of silica is ordinarily insignificant, when compared with that of carbon, and that independently of this the iron is deficient in the quantity of phosphorus and arsenic necessary for easily softening the metallic molecules, only carburet of iron and a little siliciuret of iron are produced, but the carbon does not combine with the silica. In this case the steel obtained is deficient in malleability and tenacity,—for this reason, that the molecules will not unite or crystalize until they have taken up a quantity of carbon more than sufficient to produce steel. With regard to simple carburetted iron (when it contains more carbon) it either will not harden at all when tempered, or becomes friable and brittle when heated to redness, even when it does not contain more carbon than steel of good quality.

The fracture of the steel of cementation, now under notice, is grey and dull, while steel of good quality is of a silvery aspect, and presents cubical crystals.

The best steel can only be obtained by the cementation of forged iron. Whilst the metal is combining with the carbon, the iron must not enter into a complete state of fusion, as in that case groups of crystals, each possessing a different degree of carbonization, would be formed; even the best Dannemora iron will not furnish a uniform product fit for purposes of commerce when melted with substances containing carbon. I am well aware that the experiments of Clouet, Hachette, and Bréant, may be opposed to me, as set forth in various treatises upon chemistry, but these are unfortunately mere laboratory experiments, the authors of which have prudently concealed, or passed over in silence, all those which were unsuccessful. When the operator has obtained a regulus at the bottom of his crucible, and when, after immense trouble, he has succeeded in extracting from it a small portion of steel capable of being worked, he immediately hastens to publish his pretended discovery in some journal, of which others become faithful and credulous echoes; thus, since the manu-

facture of steel has become the subject of chemical inquiry, complaints are daily becoming more frequent upon the difficulty of procuring steel capable of resisting the treatment to which it is subjected in the arts. If the persons who preside over the coining department either at London or Munich, were consulted, they would all agree in saying that it is now very difficult to meet with the quality of steel necessary for making the dies. Even in England good steel becomes more and more scarce. With regard to the manufactories of cemented or cast-steel established upon the continent, they furnish products, the quality of which is so uncertain, that the workman is often reduced, after having lost his time and trouble, to throw certain portions away, as they want the necessary uniformity and tenacity.

All the artificial alloys of steel with silver, of which so much has been said, are not fit for any thing, and are never met with in commerce.

When the steel has been withdrawn from the cementing furnace, and after it has been broken, and the pieces drawn out, they are submitted to one of the two following operations:—the pieces after being sorted are piled one upon the other and welded together, (this is called faggoting the steel,) or the sorted pieces are placed in clay crucibles of a nearly cylindrical form, and cast in a reverberatory furnace, in which two crucibles are placed, one behind the other, upon cakes of fire-clay; the orifice of these crucibles is closed by a flat cake of fire-clay. The bars of cemented steel, as above mentioned, are divided into pieces of one or two inches in length; these pieces are distributed, according to their degree of carbonization, in vessels fixed to the walls of the place in which the melting is carried on.

These different qualities of steel are generally combined in such a manner as to obtain a product the best suited for the purposes to which cast-steel is ordinarily applied.

In all treatises on practical chemistry it is asserted, that in order to melt steel, it is to be covered with a layer of glass or blast furnace slag; that the opening of the crucible is luted, or at least becomes firmly fixed during the operation; these assertions are, however, erroneous. In the first steel manufactories in Sheffield, steel only is put into the crucibles. With regard to the cover, it is evident that it must not adhere to the crucible, as it is necessary the operator should remove it from time to time with a bar of iron, in order to ascertain the state of the metal.

In order to obtain steel of the best quality, it is not sufficient that the melted mass be run into moulds: the most essential point is to make the casting at the proper time, and for this purpose the operator must be guided by the quality of the steel. This is the duty of the workman, who from long practice can tell the suitable point of fusion, either by simple inspection or by means of his bar of iron, with which he merely touches the surface of the metal, being most careful not to plunge it into the melted mass. As the quality and uniformity of the steel depend in a great measure upon the experience and judgment of the workman who directs the casting, it follows, that even in England, a good caster is much sought after and well paid.

It is not difficult, therefore, to explain why so many of the attempts made to establish manufactories of cast-steel in Germany have failed, and will again fail. Thanks to the errors propagated by technical works, and by the assertions of superficially informed travelers, who had frequently been purposely deceived, it was imagined that in order to obtain English steel of good quality, it was only necessary to melt cemented steel in a crucible, and afterwards pour it into moulds, when in a state of fusion.

As soon as a crucible is emptied, it is replaced in the oven; each crucible serves for one day's work, *i. e.*, four or five castings, after which it is thrown aside. For ordinary purposes, the steel is run into cast-iron moulds of a prismatic form, previously heated and closed. When the steel is required for making saw-blades, plates, &c., it is run into large moulds of a parallelopiped form. Steel which is very hard and highly carbonized, contracts considerably in the moulds; great skill is therefore required to run it into the moulds in such a manner that no vacuum may be produced. In that part of the prism corresponding to the jet, a funnel-shaped aperture, from one to two inches deep, is formed; this is detached and melted down with other pieces of steel.

The transverse fracture of a prism of hard steel is silvery, and has a number of rays radiating from the centre; steel less hard is on the contrary of a uniform granular and crystaline texture. This steel possesses all the brittleness of cast metal.

By fusion, steel of cementation acquires peculiar properties, and does not sweat so much as before casting.

When steel is produced from iron of bad quality, and carburets of a different nature are produced during cementation, the melting, instead of improving it, renders it much worse; as, in that case, the different carburets of iron, which are of inferior quality, separate still more during cooling. This has given rise to an old saying, well known among English founders, that "when the devil is put into the crucible, nothing but the devil will come out."

It is to the existence of these heterogeneous metallic carburets, which are produced during cementation in iron of inferior quality, and which form new combinations during the fusion of the metal, that the complaints of workmen working in steel are to be attributed. In fact, these carburets being only, so to speak, agglutinated, even in bars of forged steel, each of them, at the moment of tempering, is contracted or dilated more or less than the one immediately adjoining it, so that from that time a separation commences between the unequally carbonized layers; in other words, a flaw or crack is produced, which may be distinguished by a peculiar noise at the moment when the steel is plunged in the water, or, at least, there is a tendency to separation, which only requires the co-operation of an exterior cause, such as a shock, to effect it. This is often observed in razors, &c.

The transverse fracture of cast-steel ought to present a perfectly homogeneous surface, when the bar is broken by a sharp blow, after being cut or marked with a chisel. The slight inequalities which are perceptible ought to be undulating, and to blend insensibly at their

bases with the rest of the metallic surface. When, on the contrary, they stand out perpendicularly, the conclusion may be arrived at, that this portion of the bar was the point of contact of two unequally carbonized layers, which, by separating either at the moment of tempering, or at a later period, had inevitably given rise to this rupture.

Lond. Jour. Arts and Sciences.

Method of Extracting the Iodine and Bromine contained in the Salts and Mother Liquor of Kelp Soda.

(Translated from the Bulletin de la Société d' Encouragement.)

The Société d'Encouragement, in its general meeting of the 5th June, 1839, decreed a gold medal to *Messrs. Delaunay, Couturier, and Villedieu*, of Tourlaville, near Cherbourg, for their processes for extracting iodine and bromine from soda obtained from the sea-weed, which is gathered in large quantities on the shores of Brittany.

The importance of this manufacture was made known in a report inserted in the *Bulletin* of August, 1839; but it did not contain a description of the process. We will, therefore, make up for this omission, by giving an extract from the patent for ten years, taken by Messrs. Couturier, on the 22d May, 1835, and which has now become public property.

1st. *Extraction of Iodine from Kelp Soda.*—The mother waters of this soda having been concentrated to the greatest possible degree, are left in any suitable vessel, in order to allow the salts, which may be separated during its slow crystalization, to deposit; they are afterwards drawn off, and the small quantity of alkaline carbonate, which is always contained in these mother liquors, is saturated by means of sulphuric acid. In order to be certain that the free alkali of the mother liquors is saturated, the point of saturation must be slightly exceeded, which is ascertained when, after having sufficiently agitated the mother liquor to which the sulphuric acid has been added, a strip of litmus paper plunged into it is slightly reddened.

It often happens that the mother liquors of kelp contain a considerable quantity of hyposulphites which precipitate sulphur, and by the decomposition of which sulphurous acid is disengaged; in this case sulphuric acid is added, by small quantities at a time, until no more sulphur is precipitated. This clarified liquor is put into large vessels, which must not be quite filled, to allow the liquor to be stirred from time to time.

The bottles having been placed upon a table, a current of chlorine gas is directed to the bottom of the liquor they contain. This gas must not be disengaged too rapidly, otherwise a great part of it will be lost by traversing the liquor without being dissolved: attention to this is also necessary, in order to ascertain when to stop. It is important that the liquor should be agitated as often as possible, to enable it to combine with the chlorine gas which accumulates in the empty part of the bottles.

The chlorine gas, which is mixed with these mother liquors, acts

first upon the bases of the iodides, saturates them, and separates or precipitates the iodine; this latter appears at first in the form of a reddish substance, which thickens the liquor, but it soon forms into brown flakes, which fall to the bottom. When the liquor appears no longer to be colored red, a small quantity must be poured into a glass, and left for a time to allow the iodine floating therein to settle; after which some few drops of concentrated solution of chlorine are poured into the clarified liquor: the passage of the chlorine must be discontinued as soon as the solution ceases to thicken the mother liquor, which, on being left in a quiescent state, allows the iodine to settle at the bottom in the form of a thick layer of brilliant brown flakes.

If the iodine is required in large flakes, the supernatant liquor may be decanted off immediately, and washed in a small quantity of cold water; it is then to be put into a retort of glass or porcelain, and sublimed; a long tube of glass, of sufficiently large diameter, being adapted to the neck of the retort. The iodine is volatilized by the heat in the form of violet-colored vapors, which are first condensed in the neck of the retort, and afterwards in the tube, in the form of small plates or flakes, having a metallic lustre. When the vapors cease to be perceptible, the operation is completed: care must be taken to keep a cloth constantly wetted with cold water upon the whole surface of the tube. In working on a large scale, the products of several operations are united, left to drain, and sublimed as above described.

2d. *Extraction of the Bromine.*—The mother liquor having been completely exhausted of iodine, is introduced into a tubular retort until it is half full; powdered peroxide of manganese and concentrated sulphuric acid of commerce are to be added to it, and an apparatus composed of three recipients, which communicate by means of pipes ground with emery, is adapted to the neck of the retort: the distillation is then proceeded with, care being taken not to let it boil too fast. The bromine which is separated by this operation is volatilized and disengaged in the form of gold-colored vapors, which are partially condensed in the neck of the first receiver in the form of streaks and drops of a reddish-brown liquid, which run down by degrees into the receiver; but, as a considerable quantity of water is volatilized at the same time, it is condensed also, and floats upon the bromine, which occupies the lowest part of the liquor. When the colored vapors cease to be disengaged from the retort, the fire is removed; a fresh quantity of peroxide of manganese and sulphuric acid are then added, the retort is closed, and the fire again applied. If a sufficient quantity of these substances has been added at first, all the bromine will have been extracted; it then only remains to collect that which is below the liquor condensed in the receiver; this is done by means of a glass funnel furnished with a cock. When the separation is well effected, the end of the funnel is placed in a bottle, the cock is gently opened, and the bromine runs into the bottle; the cock is shut the instant all the bromine has run through and the water is about entering. This water holds a considerable quantity of bromine in solution, which is separated from it by collecting the residuum and

saturating it with a sufficient quantity of potash. The product of this saturation is afterwards evaporated to dryness, and the residue is calcined at a dull red heat with a small quantity of coal-dust; it is then dissolved in just a sufficient quantity of water; the solution is filtered and treated in the apparatus with peroxide of manganese and concentrated sulphuric acid, as above described.

The bromine thus obtained is rectified by means of distillation.

Lond. Journ. of Arts and Sci.

On the Theory of Photographic Action, illustrating the Connexion between the Photographic Agent and Electricity. By J. NOTT, ESQ.

Mr. Nott proceeded to say, that "since the discovery of Photography, there is, perhaps, no branch of electrical physics more interesting than that which comprehends the phenomena of phosphorescence. For though light be the apparent agent in the production of the photographic picture, yet the accompanying circumstances can only be satisfactorily explained by a reference to electrical principles. Light is a term merely relative to us; but light itself has no absolute existence any more than sound: then how unphilosophic are the terms, latent light, and light in darkness, which we sometimes hear—as if that which is merely an effect could be regarded as a cause, or as a physical force, at the same time that we know it is not possible to demonstrate the existence of any other physical force in nature than electricity. Light is, therefore, only an attendant circumstance in the production of the photographic picture; and this seems proved by the fact of one body impressing its image upon another in the dark, when the bodies are approximated at what, in electrical phraseology, is called the striking distance. As light then cannot be regarded as the photographic agent, electricity which, in all probability, is the principle of light, would seem to be; and the effects produced, when phosphorescence is developed through juxta-posed transparent media, of different densities or electrical affinities, bear so striking an analogy to those which are produced upon a sensitive surface when exposed to the action of light, reflected from bodies in different degrees of intensity, as to render it more than probable, that what is understood by the term photography, is a simple case of phosphorescence by insolation. For, as we find that some parts of the sensitive surface then exhibit what may be called an elective affinity for certain substances, while others do not, these effects can only be the result of simultaneous attractions and repulsions; the manifestation of which is inconceivable independently of the presence of electricity. The question then arises, if the photographic picture be the result of electrical action, why may not the color as well as the contour of bodies be taken down, seeing that color is not a property of matter, but is a property of light? All bodies are seen only by reflected light, and their colors vary in tint according to the position of the spectator, with respect to the plane of reflexion. For instance, in the normal of the plane of

reflexion, the color of bodies is most distinct; and at every deviation of this point the local tint changes, and, in many cases, is extinguished when the eye of the spectator reaches the angle of total reflexion. Thus, then, when the reflected light is the strongest, the color of bodies is least perceptible, and *vice versa*. These considerations induced me to try what comparative effects would be produced upon a sensitive surface by light reflected at various angles of incidence from the plane of the picture. The effects which were thus produced were analogous to those which are observed in nature; the local tints of the bodies represented varying with every change that was made in the angle of reflexion in which the picture was taken down, and the direct ray invariably gave less picturesque results then when a parallel glass was used. In some specimens taken with the parallel glass, when they were looked at directly, all the appearances of a radiating reflexion were presented; and, when looked at obliquely, all those of a specular reflexion, as if the sun were actually shining within the photographic picture itself. These results gave promise that some remarkable effects would be produced by polarized light: I, therefore, had a small sun-dial made, the style of which was formed by a bit of very fine silver wire; and from the centre of the dial a bit of the same wire was erected perpendicularly so that the hour angle and the sun's azimuth were given at the same instant. By means of this instrument, I was able to determine, with accuracy, the position of the sun with respect to the plane of the picture that I wished to make a photographic representation of; the glass of the camera was also made adjustable to the polarizing angle by an attached graduated quadrant. When, by these means, the light was polarized into the camera, by a double reflexion, from the plane of the picture and from the parallel glass, I found that the objects in deep shadow and those in sunlight were taken down simultaneously and with equal precision, without the slightest trace of solarization; exhibiting a sunlight view of the greatest truth and beauty, in which the transparency of the shadows, and the effect of distance produced by an exquisite gradation of tint, are such as Art could scarcely hope to imitate. This result of polarized light seems doubly interesting since the recent discovery of Mr. Faraday, where a ray of extinguished polarized light is re-illumined by electricity. How far this discovery may enable us to determine the nature of the active agent concerned in the production of the photographic picture, I will not, at the present moment, presume to decide."

Trans. Soc. Arts, Jan. 21st.—Athenæum.

Cast Jewellery.

At the last exhibition at Vienna of metallurgic industry in Austria, the productions of M. Glanz, who had been attached for 15 years to the royal foundry of that capital, created general admiration. His art consists chiefly in producing cast jewellery, of a most surprising delicacy. They are cast in moulds formed of very fine sand—the patterns are in bronze, and worked with great care. The cast metal,

which is used, will have a great influence on the success of this operation. That which is chiefly employed at Vienna is obtained from Maria-Zell, in Styria,—or from the royal foundry, in the environs of Halle, in the Tyrol; it is a grey metal, very compact and homogeneous. This metal is put in fusion in crucibles of plombagine (lead and silver ore mixed together); it is run into moulds so well made that every portion comes out most perfect. The additions required to be made are, by rendering them ductile with powdered charcoal in a red heat for several hours, and afterwards finished by filing. This metal, becoming malleable, can be finely polished; but it is often washed with a black varnish, and then baked in an oven. These are chiefly used for mourning jewellery. M. Glanz is not confined by the same process to casting brass trinkets, but gold and silver, and other metals, by which he saves all the trouble of the chaser. The collection is very varied—bronze figures, brooches, bracelets, necklaces, snaps, buckles, buttons, scissors, &c. This jewellery is better known under the name of Berlin, and an immense quantity is annually imported into this country and France, which, being at so reasonable a price, has nearly superseded the Birmingham ware, and the manufactures of France, where they experience so much difficulty in obtaining the proper description of metal and fuel, and that at a very high price, so as to preclude them competing with those of Vienna, Berlin, and other parts of Germany, where the art in the improvement of metal has made great progress. Lond. Min. Journ.

On the Artificial Production of Diaphanous Quartz. By M Ebelmen.

When either of the two silicic æthers which I have recently described* is exposed to the continued action of a moist atmosphere, the liquid finally solidifies to a transparent mass. This product, very delicate and fragile in the first days after its solidification, contracts more and more under the influence of the moist air, still remaining diaphanous. Two or three months are requisite in operating on 5 or 6 grms. of æther, for the substance to cease to lose in weight and for its molecular movement to terminate. The substance prepared as above is hard, faintly scratches glass, and possesses great cohesion; its lustre, its fracture and transparency are perfectly comparable to the most beautiful rock crystal. Its density is 1·77. It is a hydrate, which contains twice as much oxygen in the silica as in the water, the formula of which is consequently $(SioO)^2$ HO.

It is essential, in order that the product may not become fissured during the contraction it experiences before attaining the definite formula $(SiO)^2$ HO, not to allow the moist air to enter except by an aperture of very small diameter. During the whole of the experiment the flask containing the silicic æther exhales an alcoholic odour, which persists a long time after the solidification, proving that only a portion of the organic matter had separated from the silica when the

* See Phil. Mag. vol. xxv. p. 397.

solidification took place. The contraction proceeds the more slowly the less easily the moist air is renewed in the apparatus, and this slowness appears indispensable to the success of the operation.

From the properties of the hydrate of silica, we may be allowed to hope that it may be turned to advantage in the construction of optical instruments. It is my intention to make some experiments in this direction. Comptes Rendus, Aug. 25, 1845.—Lond. Edin. & Dub. Phil. Mag.

Expulsion of Foul Air from Mines.

An engineer (M. Halaud) has forwarded to the Academy of Sciences at Paris, a very interesting memoir on the expulsion of foul air from mines, pits, cellars, and similar places. It consists in the pumping of *steam* into places thus contaminated, which, if the foul air consists of hydrogen gas, acts merely as a forcible expeller; but if it be carbonic acid gas, the steam will also absorb that substance. As most places where deep excavations are now made, are near steam engines, the pumping of steam into mines, &c., becomes the easier. It is to be done through elastic tubes covered with india-rubber. The inventor states, that in a deep pit, where the work had been suspended by necessity for several days, the emission of steam purified it to that extent, that the workmen were able to go down as usual.

Civ. Eng. and Arch. Journ.

Proceedings of Royal Society, London.

Action of the Solar Spectrum on Vegetable Juices.—December, 1845.—In the experiments, of which the results are here reported, the solar spectrum was condensed by a lens of flint glass of seven inches and a half focus, maintained in the same part of the screen by keeping a pin-hole or pencil-mark constantly at the corner of the red rays, which were sharply defined by being viewed through blue spectacles; and the apparatus was covered with black cloth, in order to exclude extraneous light. Thick white letter paper, moistened with the liquid to be examined, was exposed wet to the spectrum, as it was found that the action of the colored light was thus rendered more immediate and more intense, than when the surface of the paper was dry. The action of the spectrum at the junction of the lavender with the violet rays, was found, in some cases, to be different from what it is with either of these colors separately, indicating a break in the continuity of action, and suggesting the idea of a secondary spectrum. In many instances the yellow and green rays exert a powerful influence on vegetable substances, an influence apparently unconnected with heat; for the darkening is generally least under the red rays, and immediately below them when the calorific rays are most abundant. The action in a great number of cases produces insulated spots in different parts of the spectrum, but more especially in the region of the rays of mean refrangibility, in which neither the calorific nor the chemical powers are the greatest. The maximum point of intensity is some-

times altered by the addition of acids, alkalies, or diluted alcohol. But altogether, as the authoress states, the action of the different parts of the spectrum seems to be very capricious, the changes of color produced being exceedingly irregular and unaccountable.

"*On New Magnetic Actions, and on the Magnetic Condition of all Matter.*" *By* MICHAEL FARADAY, ESQ., D.C.L., F.R.S. &c.—The following is the order in which the several divisions of the subject treated of in this section of the author's researches in electricity succeed one another:—1. Apparatus required. 2. Action of magnets on heavy glass. 3. Action of magnets on other substances acting magnetically on light. 4. Action of magnets on the metals generally. 5. Action of magnets on the magnetic metals and their compounds. 6. Action of magnets on air and gases. 7. General considerations.

In giving an account of the contents of this paper, any attempt to follow the track of the author in the precise order in which he relates the consecutive steps of his progress in this new path of discovery, would fail of accomplishing its object: for, by adhering to such a course, it would scarcely be possible to comprise within the requisite limits of an abstract the substance of a memoir extending, as the present one does, to so great a length, and of which so large a portion is occupied with minute and circumstantial details of experiments; or to succeed in conveying any clear and distinct idea of the extraordinary law of nature brought to light by the author, and of the important conclusions which he has deduced.

One of the simplest forms of experiment in which the operation of this newly-discovered law of magnetic action is manifested, is the following:—A bar of glass, composed of silicated borate of lead, two inches in length, and half an inch in width and in thickness, is suspended at its centre by a long thread, formed of several fibres of silk cocoon, so as to turn freely, by the slightest force, in a horizontal plane, and is secured from the agitation of currents of air by being enclosed in a glass jar. The two poles of a powerful electro-magnet are placed one on each side of the glass bar, so that the centre of the bar shall be in the line connecting the poles, which is the line of magnetic force. If, previous to the establishment of the magnetic action, the position of the bar be such that its axis is inclined at half a right angle to that line, then, on completing the circuit of the battery so as to bring the magnetic power into operation, the bar will turn so as to take a position at right angles to the same line; and, if disturbed, will return to that position. A bar of bismuth, substituted for the glass bar, exhibits the same phenomenon, but in a still more marked manner. It is well known that a bar of iron, placed in the same circumstances, takes a position coincident with the direction of the magnetic forces; and therefore at right angles with the position taken by the bar of bismuth subjected to the same influence. These two directions are termed by the author *axial* and *equatorial*; the former being that taken by the iron, the latter that taken by the bismuth.

Thus it appears that different bodies are acted upon by the mag-

netic forces in two different and opposite modes; and they may accordingly be arranged in two classes; the one, of which iron is the type, constituting those usually denominated *magnetics;* the other, of which bismuth may be taken as the type, obeying a contrary law, and therefore coming under the generic appellation of *diamagnetics.* The author has examined a vast variety of substances, both simple and compound, and in a solid, liquid, or gaseous form, with a view to ascertain their respective places and relative order with reference to this classification. The number of simple bodies which belong to the class of magnetics is extremely limited, consisting only of iron, which possesses the magnetic property in an eminent degree, nickel, cobalt, manganese, chromium, cerium, titanium, palladium, platinum and osmium. All other bodies, when either solid or liquid, are diamagnetic; that is, obey the same law, with regard to magnetic action, as bismuth, but with various degrees of intensity: arsenic is one of those that give the feeblest indications of possessing this property. The following exhibit it in increasing degrees, according to the order in which they are here enumerated; namely, ether, alcohol, gold, water, mercury, flint glass, tin, lead, zinc, antimony, phosphorus, bismuth. On the other hand, no gaseous body of any kind, or in any state of rarefaction or condensation, affords the slightest trace of being affected by magnetic forces. Gases may therefore be considered as occupying the neutral point in the magnetic scale, intermediate between magnetic and diamagnetic bodies.

The magnetic properties of compound bodies depend on those of their elements; and the bodies are rendered either magnetic or diamagnetic, according to the predominance of one or other of these conditions among their constituent parts. Thus iron is found to retain its magnetic power when it has entered into combination with other bodies of the diamagnetic class; the two forces acting in opposition to one another, and the resulting effect being only that due to the difference in their power. Hence the oxides and the salts of iron are still in a certain degree magnetic, and the latter even when they are held in solution by water; but the water may be present in such a proportion as that neither shall prevail; and the solution, as far as respects its magnetic properties, will then be exactly neutralized. These saline solutions, prepared of various degrees of strength, also afford a convenient method of comparing the relative degrees of force, both magnetic and diamagnetic, of different bodies, whether solid or fluid, but more especially the latter, as they admit of the body under examination being suspended in another liquid, when its position of equilibrium will indicate which of the two substances has the strongest magnetic power.

In one respect, indeed, the diamagnetic action presents a remarkable contrast with the magnetic; and the difference is not merely one of degree, but of kind. The magnetism of iron and other magnetics is characterized by polarity; that of diamagnetics is devoid of any trace of polarity; the particles of two bodies of the latter class, when jointly under the influence of the magnetic forces, manifest towards each other no action whatever, either of attraction or repulsion. It has

long been known that the magnetism of iron is impaired by heat; and it has been generally believed that a certain degree of heat destroys it entirely. The author finds, however, that this opinion is not correct; for he shows that, by applying more powerful tests than those which had been formerly confided in, iron, nickel and cobalt, however high their temperature may be raised, still retain a certain amount of magnetic power, of the same character as that which they ordinarily possess. From the different temperatures at which the magnetic metals appear to lose their peculiar power, it had formerly been surmised by the author that all the metals would probably be found to possess the same character of magnetism, if their temperature could be lowered sufficiently; but the results of the present investigation have convinced him that this is not the case, for bismuth, tin, &c., are in a condition very different from that of heated iron, nickel or cobalt.

The magnetic phenomena presented by copper and a few other metals are of a peculiar character, differing exceedingly from those exhibited by either iron or bismuth, in consequence of their being complicated with other agencies, arising from the gradual acquisition and loss of magnetic power by the iron core of the electro-magnet, the great conducting power of copper for electric currents, and its susceptibility of being acted upon by induced currents of magneto-electricity, as described by the author in the first and second series of these researches. The resulting phenomena are to all appearance exceedingly singular and anomalous, and would seem to be explicable only on the principles referred to by the author.

Pursuing his inductive inquiries with a view to discover the primary law of magnetic action from which the general phenomena result, the author noticed the modifications produced by different forms given to the bodies subjected to experiment. In order that these bodies may set either axially or equatorially, it is necessary that their section, with reference to the plane of revolution, be of an elongated shape: when in the form of a cube or sphere they have no disposition to turn in any direction: but the whole mass, if magnetic, is attracted towards either magnetic pole; if diamagnetic, is repelled from them. Substances divided into minute fragments, or reduced to a fine powder, obey the same law as the aggregate masses, moving in lines, which may be termed *diamagnetic curves*, in contradistinction to the ordinary magnetic curves, which they everywhere intersect at right angles. These movements may be beautifully seen by sprinkling bismuth in very fine powder on paper, and tapping on the paper while subjected to the action of a magnet.

The whole of these facts, when carefully considered, are resolvable, by induction, into the general and simple law, that while every particle of a magnetic body is attracted, every particle of a diamagnetic body is repelled, by either pole of a magnet. These forces continue to be exerted as long as the magnetic power is sustained, and immediately cease on the cessation of that power. Thus do these two modes of action stand in the same general antithetical relation to one another as the positive and negative conditions of electricity, the

northern and southern polarities of ordinary magnetism, or the lines of electric and of magnetic force in magneto-electricity. Of these phenomena, the diamagnetic are the most important, from their extending largely, and in a new direction, that character of duality which the magnetic force was already known, in a certain degree, to possess. All matter, indeed, appears to be subject to the magnetic force as universally as it is to the gravitating, the electric, the cohesive and the chemical forces. Small as the magnetic force appears to be in the limited field of our experiments, yet when estimated by its dynamic effects on masses of matter, it is found to be vastly more energetic than even the mighty power of gravitation, which binds together the whole universe: and there can be no doubt that it acts a most important part in nature, and conduces to some great purpose of utility to the system of the earth and of its inhabitants.

Towards the conclusion of the paper, the author enters on theoretical considerations suggested to him by the facts thus brought to light. An explanation of all the motions and other dynamic phenomena consequent on the action of magnets on diamagnetic bodies might, he thinks, be offered on the supposition that magnetic induction causes in them a state the reverse of that which it produces in magnetic matter: that is, if a particle of each kind of matter were placed in the magnetic field, both would become magnetic, and each would have its axis parallel to the resultant of magnetic force passing through it; but the particle of magnetic matter would have its north and south poles opposite to, or facing the contrary poles of the inducing magnet; whereas, with the diamagnetic particles, the reverse would obtain; and hence there would result, in the one substance, approximation; in the other, recession. On Ampére's theory, this view would be equivalent to the supposition that, as currents are induced in iron and magnetics, parallel to those existing in the inducing magnet or battery wire, so, in bismuth and other diamagnetics, the currents induced are in the contrary direction. As far as experiment yet bears upon such a notion, the inductive effects on masses of magnetic and diamagnetic metals are the same.

"*On the Use of the Barometric Thermometer for the determination of Relative Heights.*" *By* James R. Christie, Esq.—*January 29th.*—The objects of this communication, as stated by the author, are, first, to show the theoretical foundation of the very simple law pointed out by Professor Forbes, according to which the difference of the boiling temperature of water at two stations is connected with their difference of level; and next, to test the accuracy of this law by a comparison of results deduced from his own observations on the boiling-point of water at different stations among the Alps of Savoy, Piedmont and Switzerland, with the heights of the same stations as determined by other observers and by different means; and thus to arrive at a just conclusion with respect to the value of the barometric thermometer as an instrument for determining differences of level.

Combining DeLuc's formula reduced to English units,

$$b = \frac{99}{\cdot 899} \log 10\,\beta - 60{\cdot}804,$$

where b is the variable boiling-point on Fahrenheit's scale and β the corresponding barometric pressure, with the formula of Laplace for the determination of the difference in level of two stations from barometric observations, he obtains the formula

$$H = 547{\cdot}99\,(b - b')\left\{1 + (t - 32^\circ)\cdot 00222\right\},$$

where b and b' are the boiling-points on Fahrenheit's scale at the two stations, t the mean temperature of the air at the stations, and H their difference of level in English feet.

The author describes the particular instrument he employed in his observations, and his mode of determining the correction which it required; and then gives, in a table, the observations he made on the boiling-point of water at thirty-eight different stations in the Alps; the heights of the corresponding stations above the sea level, deduced from these observations; and, for the purpose of comparison, the heights of the same stations deduced by other observers. The difference between these and some of the author's results are considerable; but as they are not greater than would probably arise from ordinary barometric measurements, and as there is a close accordance between his results and the determinations on which the greatest reliance can be placed, he concludes that the results are on the whole satisfactory. Considering it, however, desirable to obtain some test of the accuracy of each observation independently of the rest of the series, the author avails himself of the barometric observations made at the Observatory at Geneva and at the Convent of the Great St. Bernard; and determining from these the corresponding temperature of boiling water, deduces the difference of level between each of his stations and these two places considered as fixed points: the sum of the height above Geneva and the depression below the Great St. Bernard should in all cases be the difference of level between the two fixed stations. Although there are here again considerable discrepancies, yet in most cases, where the height of the station may be considered as well established, the height deduced from the observations agrees with it in a very remarkable manner.

In another table, the author gives the difference of level between the Observatory at Geneva and the Great St. Bernard, deduced from the recorded observations at those places simultaneous with his own at his various stations; and then remarks that the differences of height determined by the two methods do not differ from one another, in any single case, by so large a quantity as do the greatest and least differences of height deduced from the barometric observations; while in many cases the accordance is almost perfect.

The conclusion drawn from the comparisons in these tables is, that the barometric thermometer is capable of affording highly accurate and satisfactory results, perhaps even more so than the common form of barometer, but that there is considerable uncertainty attached to its

indications. This uncertainty, far from being wholly attributable to the imperfections of the instrument as a measure of the atmospheric pressure, might, the author thinks, arise from an extreme susceptibility to rapid changes in that pressure, which remain unindicated by the more sluggish barometer.

"*On the Electro-Chemical Protection of Metals.*"—*Jan.* 30.—The chief subject of Prof. Brande's communication was, the description and philosophical explanation of the protection given to iron by coating it with zinc. The researches of Sir H. Davy in the years 1824–25 were noticed, and the effects of sea-water on copper, simply immersed in that liquid, were contrasted with the protection afforded to it by a cemented plate of zinc or iron. It was then demonstrated that, whenever two metals, possessing unequal affinity for oxygen, are brought into metallic contact in any medium containing oxygen, an electrical current is produced; that this current passes from the more oxidizable to the less oxidizable metal; and that the latter is protected by the increased corrosion of the former. Thus, the interior of a copper stew-pan will not be affected by acids so long as any of its tinning remains; while, on the contrary, if what is called tin-plate (*i. e.* iron plate coated with tin) be scratched, however slightly, the iron is quickly corroded, the cuticle of tin being protected at the expense of the metal which it was designed to preserve. Now, *zinc* on *iron* is what *tin* is on *copper*,—a perfect protection, so long as any remains on its surface. It was then shown that, generally, the direction of an electric current depended, not only on the metals, but on the nature of the medium through which the current passed (*e. g.* on whether an acid, or a solution of sulphur, or of any other electro-negative substance was used.) Instances of metallic deposition by chemical affinity, as that of lead on zinc, of copper on iron, &c., were exhibited; and it was shown that, whenever the electric current was superinduced by the employment of a conductor of electricity, whether metallic or not, the metal passed to the conducting (or the electro-negative) surface (the cathode of Faraday.) The process of zincing iron was then exhibited. The metal is carefully scoured, steeped in dilute acid, washed in water and thoroughly dried, and then plunged into melted zinc. As it is necessary that there should be perfect metallic contact between the metals, sal-ammoniac is sprinkled over the melted zinc before the immersion of the iron. This covers the liquid metal with a film of chloride of zinc, which precludes intervening oxide, and thus insures perfect adhesion between the coating and coated metals. Prof. Brande concluded his communication by exhibiting zinced iron piping, and by mentioning instances of the successful application of this invention, as in the cases of the iron roofing of the Houses of Parliament, the buoys used by the Trinity House, wires of galvanic telegraphs, &c.

"*On the Influence of the Solar Rays in producing Chemical or Molecular Change*".—*Feb.* 13.—Having briefly sketched the progress of philosophical inquiry into the chemical influence of the solar